Hill County
Traffic Safety Improvements Study

prepared by Robert Peccia & Associates
Helena, Montana
September, 1989

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Traffic Safety Improvements Study

Prepared for:

Hill County, Montana

In cooperation with:

State of Montana Department of Justice
Highway Traffic Safety Division
and the
Montana Association of Counties

September, 1989

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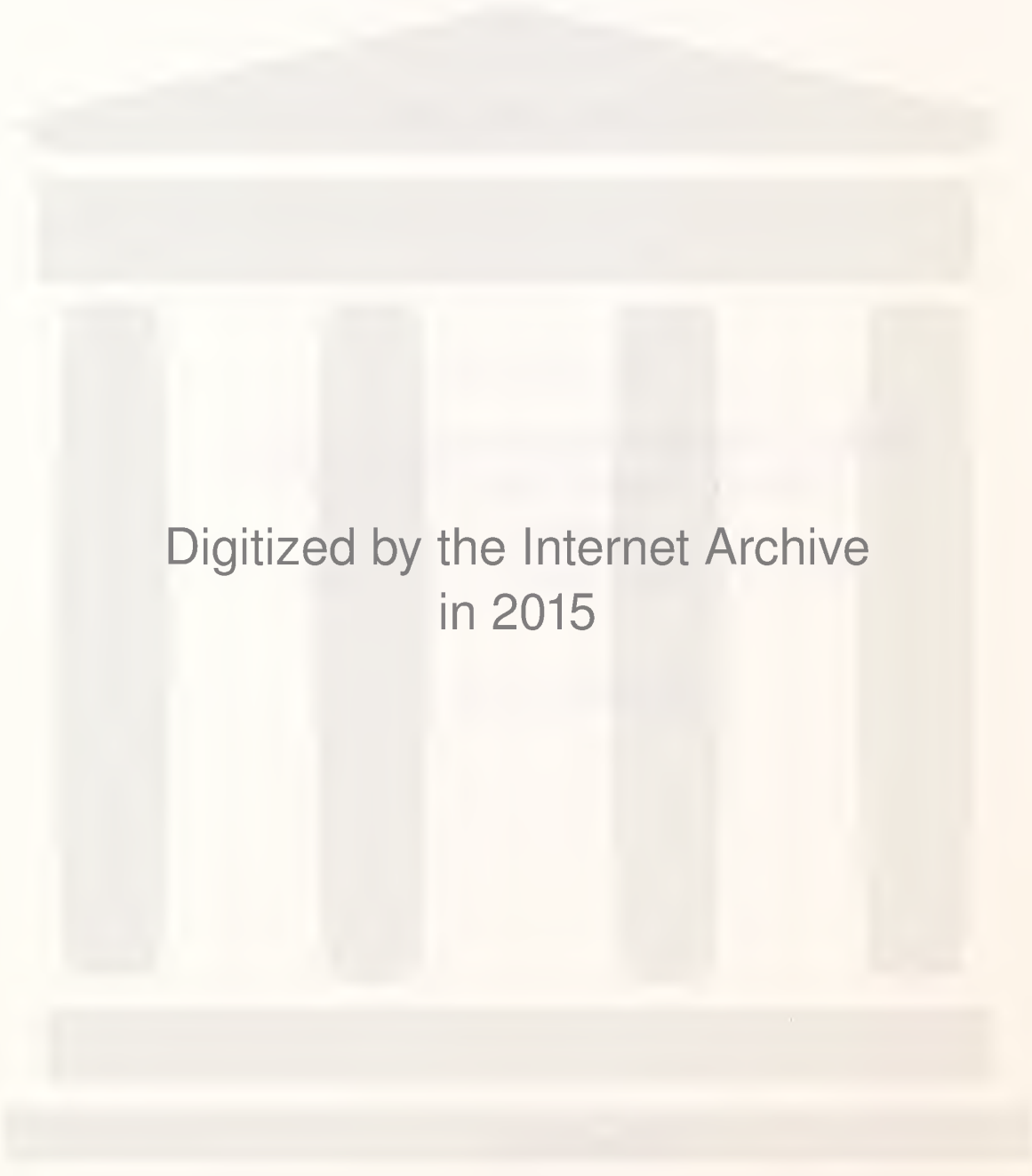

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Chapter I: Introduction and Purpose

The Highway Traffic Safety Division of the Montana Department of Justice is currently conducting several traffic safety studies in various counties throughout the state. These studies are intended to assist the counties by identifying high-accident frequency locations on the county road system and developing a set of recommendations that address the safety problems at these locations.

The purpose of this study was to analyze the accident history of the Hill County road system, identify locations where a high frequency of accidents occur, and conduct a detailed examination of 10 problem sites.

The results of the individual site analyses include both short- and long-term recommendations that address the problems identified at each location. The comments and recommendations contained in this document are intended to assist Hill County in reducing the number and severity of traffic accidents at these locations through the use of national safety standards and practices.

Chapter II: Summary of Recommended Improvements and Implementation

The accident studies undertaken for this project included an examination of approximately 245 accidents that occurred on the Hill County road system during the period from January, 1985 through December, 1988. An accident cluster map, which was developed to help identify the locations of the accidents, revealed few problem areas on the county road system. The large majority of the accidents occurred at random locations throughout the county.

The focus of this study was to identify safety problems and deficiencies at 10 specific accident locations in Hill County. The ten locations selected for this project account for 55 accidents which represents approximately 22% of all county traffic accidents.

A set of improvements was developed to address the problems at each site. These improvements are primarily intended to provide positive guidance to the motorist through the use of conventional signing and striping techniques and to improve the sight distance within the existing roadway. In some cases the problems at a particular site could not be completely corrected by a short-term improvement. In these cases, both short- and long-term improvements were recommended. The total cost (in current dollars) of the short-term improvements is estimated to be $16,600.00. The long-term improvement costs are estimated to be $345,000.00. The costs of the recommended improvements for each site are shown in the following table:

Table 1
Site Improvement Costs

Site No.	Site Description	Short-Term Improvement Cost	Long-Term Improvement Cost
1	1st St. N. & 8th Ave. N.	$ 1,420	$ 25,000
2	1st St. N. & 13th Ave. N.	780	--
3	22nd Ave. NE & BN Railroad	6,560	30,000
4	2nd St. W. & County Rd. 651	695	--
5	Boulevard Ave. & County Rd. 651	1,030	150,000
6	11th St. & 16th Ave. W.	1,970	50,000
7	Clear Creek Rd.	950	65,000
8	Clear Creek Rd. & Bull Hook Rd.	460	25,000
9	Main St., Box Elder	1,955	--
10	Taylor Rd.	780	--
	Total Estimated Costs	**$16,600**	**$345,000**

A priority ranking has been provided to assist the County in determining an order for implementing the recommended improvements. This ranking considered the relative hazardousness of each site and the cost of the improvements to prioritize the site improvement projects. Due to the nature and cost of the long-term improvements, only the short-term improvements were considered in the priority ranking process. The relative hazardousness of each site was evaluated through the calculation of a hazard index. This hazard index was based on three accident indicators (number of accidents, accident severity, and accident rate) and four non-accident indicators (volume/capacity ratio, sight distance ratio, driver expectancy, and information system deficiencies). A detailed explanation of the factors involved in calculating the hazard index and priority index is presented in Appendix A of this report. The benefit/cost ratio, hazard index, and priority ranking for each site are shown in the following table:

Table 2
Priority Ranking

Priority Ranking	Site No.	Site Description	Short-Term Improvement Cost	Hazard Index	Priority Index	Benefit/Cost Ratio
1	3	22nd Ave. NE & BN Railroad	6,560	63.21	68.66	19.43
2	10	Taylor Rd.	780	52.45	65.24	6.45
3	1	1st St. N. & 8th Ave. N.	1,420	50.46	62.60	6.80
4	4	2nd St. W. & County Rd. 651	695	48.06	61.05	39.11
5	9	Main St., Box Elder	1,955	44.11	57.58	5.51
6	8	Clear Creek Rd. & Bull Hook Rd.	460	43.41	57.53	1.50
7	5	Boulevard Ave. & County Rd. 651	1,030	40.46	55.35	1.55
8	7	Clear Creek Rd.	950	39.57	54.18	13.61
9	2	1st St. N. & 13th Ave. N.	780	29.19	46.64	7.63
10	6	11th St. & 16th Ave. W.	1,970	25.92	44.44	0.35

A benefit/cost ratio was calculated for the improvements at each site. This ratio is greater than one in all but one case, Site 6. This is a result of the fact there was one accident (property-damage-only) at this site, and the ratio is based on the potential reduction of the accidents that occurred at the site. Although the benefit/cost ratio is less than one at Site 6, the improvements are considered desirable with respect to traffic safety.

Chapter III: Site-Selection Process

The Consultant collected the Montana Highway Patrol accident records for all the traffic accidents that occurred on the Hill County road system during the period from January 1, 1985 through December 31, 1988. These reports were reviewed to determine the location of each accident. The accident locations were plotted on county road maps and used to locate accident clusters which represented potential problem areas.

The County Road Superintendent and a representative from the State Highway Traffic Safety Division met with the Consultant in Havre to review the accident data and select 10 sites for further study. A tour of the potential study locations was conducted after a review of the plot maps and the accident records. At the conclusion of this tour, the 10 sites to be evaluated were selected by the Consultant and approved by the County Road Superintendent. Site selection was based on accident history, accident severity, and the Superintendent's local knowledge of problem areas on the county road system.

Eight of the study sites are located in the immediate vicinity of the city of Havre. The other two sites are located near the southern boundary of the county, one in the community of Box Elder and the other on Taylor Road, east of the community of Rocky Boy. The location of each site is listed below and shown on Figures 1 and 2:

Site 1: 1st Street North and 8th Avenue North
Site 2: 1st Street North and 13th Avenue North
Site 3: 22nd Avenue North and Burlington Northern Railroad Crossing
Site 4: 2nd Street West and County Road 651
Site 5: Boulevard Avenue and County Road 651
Site 6: 11th Street and 16th Avenue West
Site 7: Clear Creek Road
Site 8: Intersection of Clear Creek Road and Bull Hook Road
Site 9: Main Street, Box Elder
Site 10: Taylor Road

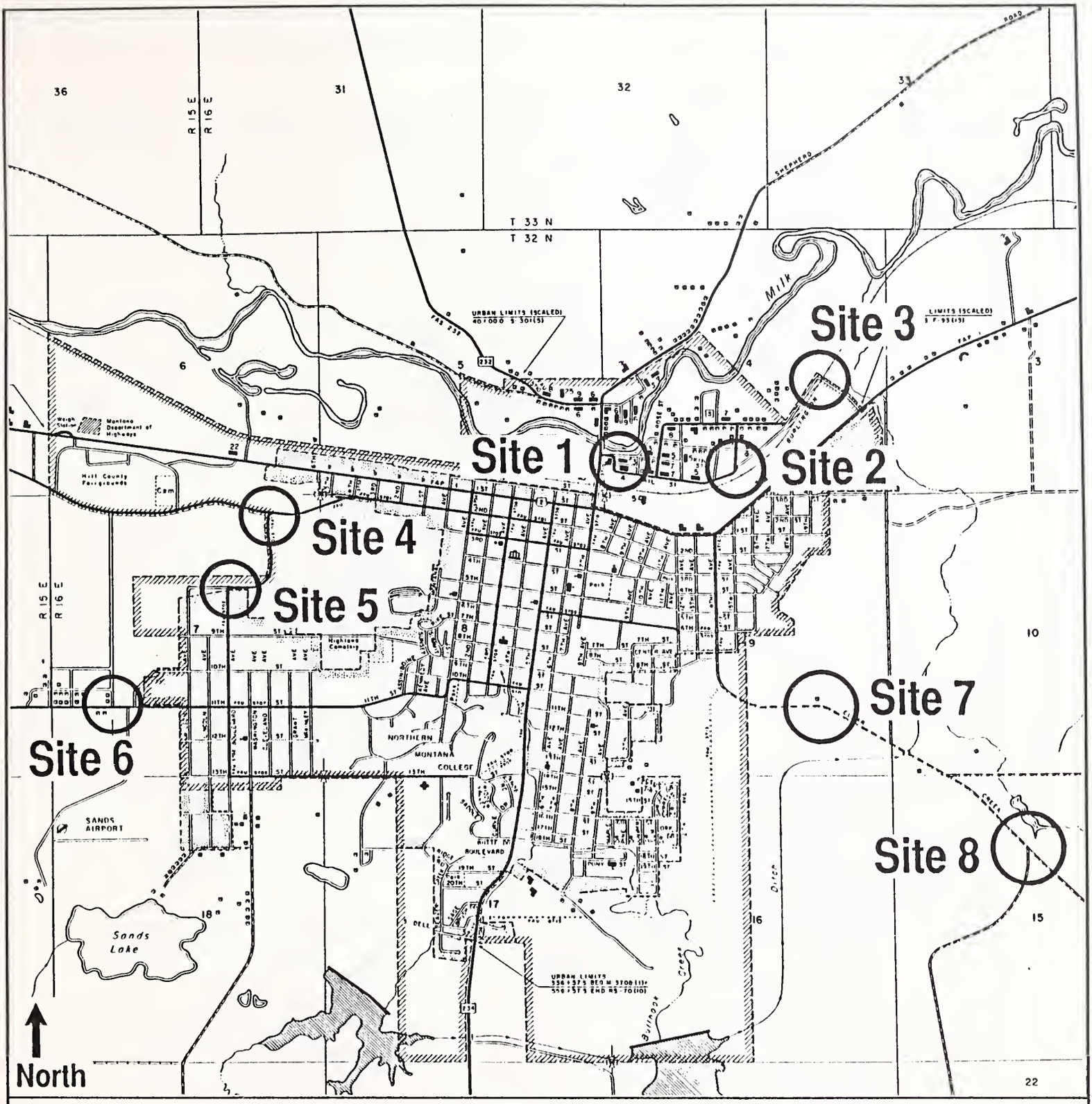


Figure 1
Site Location Map

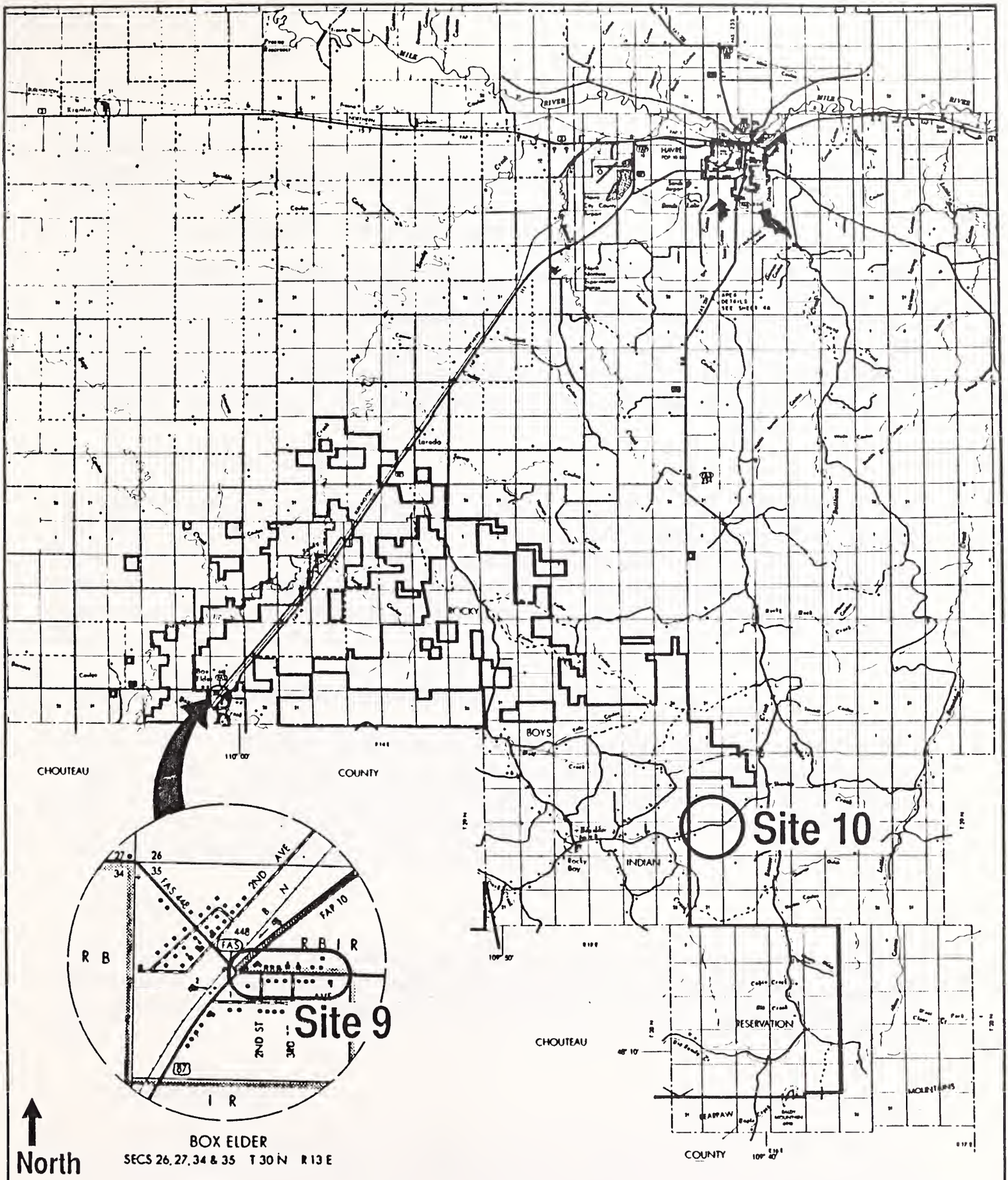


Figure 2
Site Location Map

Chapter IV: Study Methodology

A. Field Investigation and Data Collection

The data-gathering procedure used during this study included: 1) initial accident research; 2) initial site visit and site identification; 3) site survey; 4) site photography; 5) detailed site sketch; 6) traffic counts; 7) on-site accident analysis; 8) ball bank testing; 9) sight distance determination; 10) subjective rating of site drivability and physical layout; and 11) observation of driver characteristics and quality of travel. The following section contains a brief explanation of each activity undertaken during the data-collection stage of this project.

1. Initial Accident Research

The initial accident research consisted of a review of all traffic accidents that occurred on Hill County roads during the period from January 1, 1985 through December 31, 1988. The Consultant collected copies of the accident records from the files at the Montana Department of Justice. The location of each accident was then plotted on a county road map. This map was used to locate accident clusters which represent potential problem areas.

2. Initial Site Visit and Site Identification

The initial visit to each cluster area was made by the Consultant with the County Road Superintendent and a representative of the Montana Department of Justice. At this time, the specific study locations were identified based on the accident reports and the input of the Road Superintendent, whose firsthand knowledge of the long-term accident history and traffic characteristics at each site was very beneficial.

3. Site Survey

Survey equipment was used to identify the physical layout of the roadway. Data gathered during the site survey included average road grades within the site, roadway alignment, superelevation in curves, roadway widths, and identification of approximate right- of-way widths.

4. Site Photography

During site visits, photographs were taken to illustrate site characteristics or to identify deficiencies within the site. These photographs were utilized in many ways during the preparation of the report and its graphics. Aerial photography at the largest scale possible was obtained and used during base map preparation and site analysis.

5. Site Sketch

This phase of the data collection involved field measurements of site details including sign locations, pavement markings, roadside delineators, utilities adjacent to the roadway, fencing, and roadside vegetation. Site photography was also extensively utilized to produce accurate sketches.

6. Traffic Counts

Available traffic count data was obtained from the Planning and Statistics Bureau of the Montana Department of Highways and used for as many sites as possible. For those sites lacking such information, 4-hour, manual counts were taken at the required locations. If the site included a major intersection and traffic was significant, peak hour turning movements were conducted. This traffic data was used to estimate the average daily traffic (ADT) and for the capacity analysis.

7. Accident Analysis

All reported accidents at each study location that occurred during the study period of January 1985 through December 1988 were plotted on collision diagrams. Accident data for the study period was also summarized and used in the field. These summaries allowed the traffic engineer to reconstruct the accidents and to better understand the circumstances that made for unsafe driving conditions at a particular site. The number of accidents and traffic volumes were used to establish accident rates of the specific sites.

8. Ball Bank Testing

The vehicle utilized during field data collection was equipped with a ball bank indicator or safe curve speed indicator. This instrument provides a simple way to establish the maximum safe speed for a particular curve. All recommended advisory speeds on curves were verified through the use of this instrument.

9. Stopping Sight Distance Determination

The available sight distance was measured and recorded at each study location. Stopping sight distance is the minimum distance needed for a vehicle traveling near or at the design speed for the roadway to stop for an object in its path. Vehicle speed, roadway surface conditions, obstructions, and driver characteristics were also considered in the sight distance measurements. The measurement of sight distance at intersections required the development of minimum sight triangle, which considers unobstructed sigh distance along both roads at an intersection and across the included corner.

10. Subjective Rating of Site Drivability and Physical Layout

Before the field data was gathered for each site, two field technicians independently rated the drivability of the site and the completeness of the information system presented to motorists entering the site. These ratings were computed using the Driver Expectancy and Information System Deficiencies forms, which are discussed in Appendix A of this document. These ratings present a relatively unbiased impression of the site layout and characteristics, since they were arrived at independently by technicians who were not familiar with the site prior to the data-collection phase of the project.

11. Observation of Driver Characteristics and Quality of Travel

During the collection of field data, time was taken to observe motorists' driving habits through each site. Field observations of drivers were taken both during day and nighttime light conditions to obtain an overall impression of driver tendencies and to detect deficiencies in the overall layout of the site.

B. Data Analysis and Development of Priority Index

The ultimate objective of the site evaluations was to identify safety problems and deficiencies that contribute to the occurrence of traffic accidents. After the problems and deficiencies at each site were identified, recommended improvements were developed. These improvements are based on national traffic safety standards and procedures as defined in the Manual on Uniform Traffic Control Devices (MUTCD).

The improvements at the 10 sites were prioritized to assist Hill County in determining the order of implementation.

A procedure based on methods outlined in an FHWA report, entitled Identification of Hazardous Locations (Report No. FHWA-RD-77-83), was used to develop an order for implementing improvements at the high-accident locations. This procedure considered the relative hazardousness of the site and the cost of recommended improvements at each location to determine the order for implementing projects.

This ranking, known as the priority index, was based on the development of a hazard index and a cost factor for each site. The hazard index calculation considered 3 accident indicators (number of accidents, accident rate, and accident severity) and 4 non-accident indicators (volume to capacity ratio, sight distance ratio, driver expectancy, and information system deficiencies). A value, ranging from 0 to 100 with 0 representing no hazard and 100 representing the most hazardous condition, was assigned to each indicator. The indicator values were then weighted and totaled to yield the hazard index. The cost factor represents the improvement cost per vehicle and is computed by dividing the total cost for the recommended improvements by the number of vehicle entering the location during the service life of the improvements.

The priority index, a weighted average of the hazard index and the cost factor, evaluates the relative hazardousness of each site and the cost of recommended improvements. This index was used to rank each site and should be the primary guide for implementing improvements at the 10 study locations. A benefit/cost ratio for the recommended improvements at the sites was also calculated.

The priority index and the benefit/cost ratio calculations are based only on the short-term improvements recommended for each site. Long-term improvements were not prioritized due to the uncertain costs and time frames involved in each recommendation.

An explanation of each hazard indicator and the forms or tables used to determine the hazard index, cost factor, priority index, and benefit/cost ratio are presented in Appendix A of this report.

Chapter V: Site Analysis

A. General

The following narrative contains a discussion of the physical layouts, the operational characteristics, and the accident histories for 10 locations in Hill County. This information, combined with the results of various on-site traffic studies, was used to identify the cause of the accidents at each site. The recommended improvements are intended to address any identified safety problems or deficiencies and thereby reduce the frequency and severity of accidents at each location. Most of the recommendations involve limited construction and are designed to provide direct benefits to the motorists using the county road system. The improvements are generally low-cost items and should be easily implemented by county personnel. Coordination with state and city highway departments will be required at some locations because some recommendations fall outside of county jurisdiction. Full implementation of the recommendations contained in this document will depend upon the response and coordination of these other agencies.

B. Individual Site Evaluations

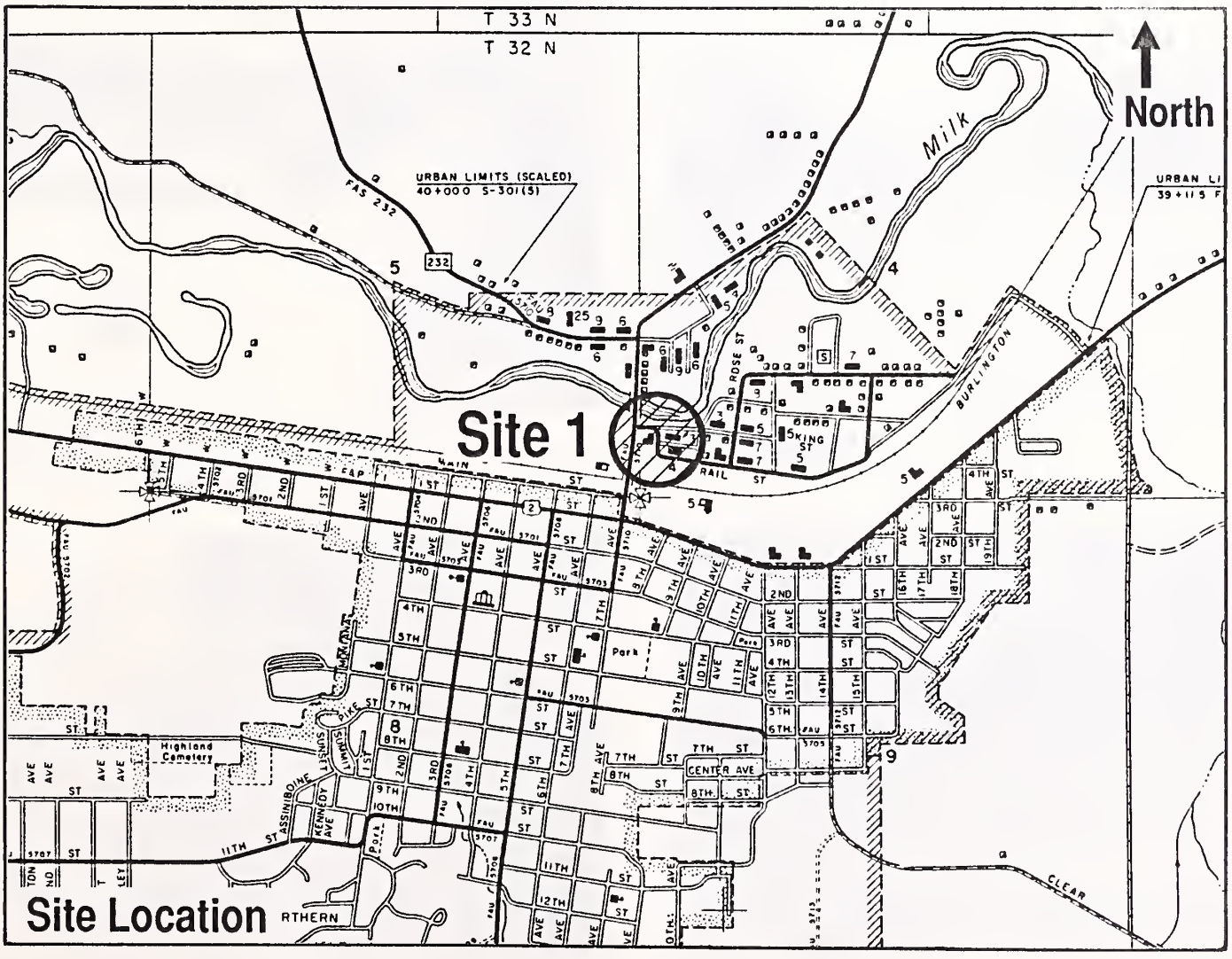
The evaluation of each study site contained in the following pages consists of 1) a discussion of the existing physical features; 2) a summary of the site's accident history with a table listing important accident characteristics; 3) a site sketch showing the site geometrics, physical features, and the location of each of the site accidents; 4) site photographs; 5) a list of recommended improvements including estimated costs; 6) a figure identifying all recommended improvements; and 7) the calculations of the hazard index. A benefit/cost ratio for the improvements at each site has also been provided.

Site 1

Site 1
Existing Conditions

Site 1, located one-fourth mile north of U.S. Highway 2 in Havre (see map below), consists of the intersection of First Street North and Eighth Avenue North. Eighth Avenue, a 26-foot-wide paved road, connects Seventh Avenue (FAS 232) with First Street, a main access route to much of the residential community in this area. First Street also extends west of the Eighth Avenue intersection where it changes from pavement (26-feet-wide) to gravel and acts as an access road for two businesses. Second Street North, which is a gravel residential street, also intersects Eighth Avenue in the vicinity of this site as shown in Figure 1A. Eighth Avenue North slopes away from Seventh Avenue at a grade of approximately 4% while all other areas within the site have grades less than 1%. Sight distance is limited at the intersection of First Street and Eighth Avenue because of the Christian Armory Building located on the northeast corner of the intersection.

At the time of the field investigtion, the pavement was in poor condition. The pavement markings, which consist of a double-solid yellow centerline, were also in poor condition and barely visible in some areas.



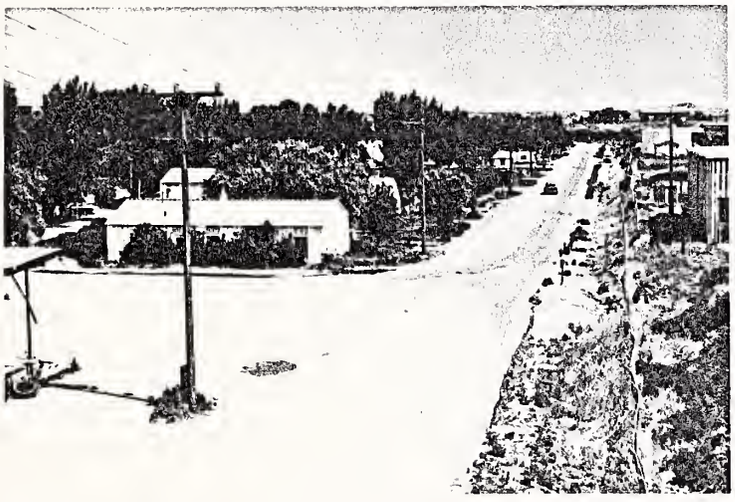
Site Photographs

Photograph 1: This view of the site from the viaduct shows the long straight approach to the intersection on First Street North. The white building on the corner limits the sight distance at the intersection.

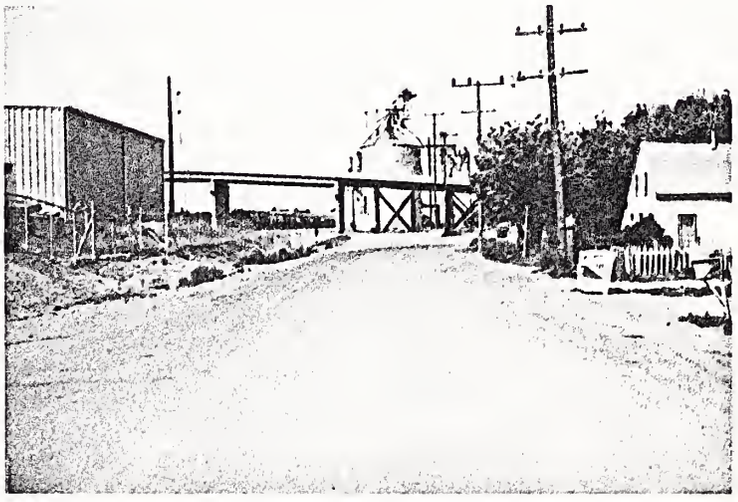
Photograph 2: It is hard to locate the intersection when approaching from the east. There is no intersection signing on this approach.

Photograph 3: Surface runoff tends to pond on the inside of the curve. The pavement in the intersection is in poor condition with numerous potholes. Centerline striping has been completely worn off by vehicles crossing over it to avoid bad spots in the road.

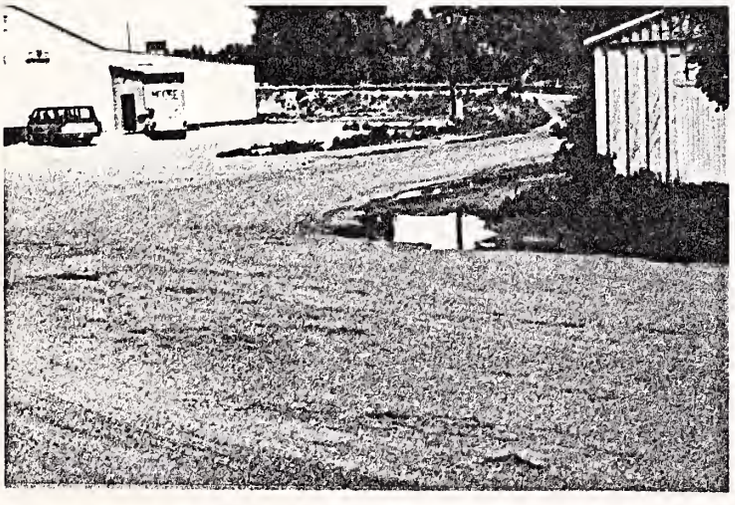
Photograph 4: A series of amber reflectors have been installed behind the guardrail on Eighth Avenue North. Amber reflectors are normally used to delineate the left side of a one-way road. White reflectors should be used at this location.



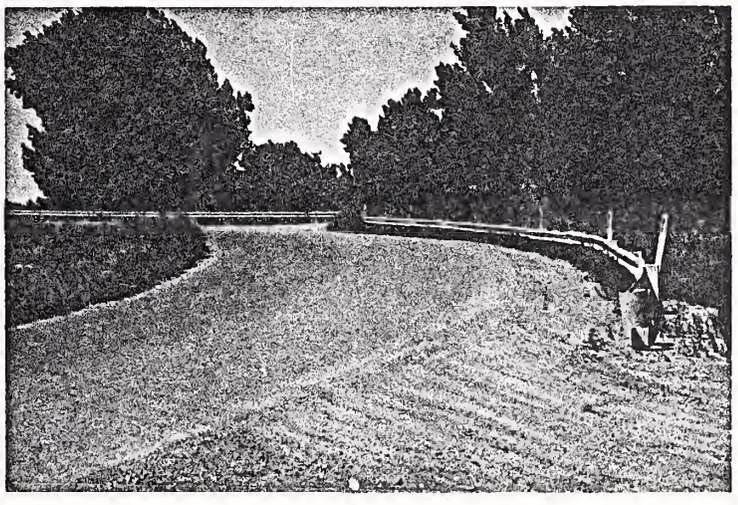
Photograph 1



Photograph 2



Photograph 3



Photograph 4

Accident History

Seven multi-vehicle accidents occurred at this site during the four-year study period. There were three angle collisions, two sideswipes, and two cases where a vehicle backed out of a driveway and struck a passing car. The collision diagram in Figure 1A shows the location of each accident at this site. The three-angle accidents accidents occurred at the intersection of First Street and Eighth Avenue. One of these collisions resulted in injuries to four people. Excessive speed was the cause of two of these angle accidents. Alcohol was involved in two of the seven accidents. The data below shows additional facts relating to the four-year accident history at this location.

ACCIDENT DATA

SITE 1: First Ave. N. & Eighth Ave. N. **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
3	1		3

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
1	3	1		1	1	

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							1	1	1	2	1

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
									1		1		1	1		1			1				

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
5	2		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
2	2		3	

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
5	1	1	

NO. OF ACCIDENTS BY ACCIDENT TYPE

Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
3					2			2	

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
1	2		2			2		

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)				1 (4)	1 (4)
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.	3	1		2	6

The accident history at this site is of particular interest because this location was evaluated in a similar safety study in 1982. That study was based on a four-year accident history from January 1978 through December 1981. During that time, a total of nineteen accidents were reported at this site compared with only seven accidents reported during the current study period (1985 through 1988).

The nineteen accidents involved in the previous study included eight angle collisions at the intersection of Eighth Avenue and First Street, six multi-vehicle collisions in the broad curve on Eighth Avenue, and five fixed-object collisions. A list of improvements were recommended in that study to address problems at the site. The County implemented a majority of the improvements including the installation of warning signs, reflectorized delineators, and pavement markings at a cost of approximately $1,690.00. These improvements have resulted in a 63% reduction in the number of accidents at this site. This reduction translates into a savings of approximately $39,000.00 based on the National Safety Council's estimates on accident costs. Those improvements produced a savings of $23.00 in accident costs for each dollar spent on this site.

ESTIMATED AVERAGE DAILY TRAFFIC
1200 VPD

SYMBOLS
VEHICLE PATH
PEDESTRIAN PATH
BACKING VEHICLE
PARKED VEHICLE
FIXED OBJECT
FATAL ACCIDENT
INJURY ACCIDENT (No. Injured)

COLLISION TYPES
REAR END
HEAD ON
SIDE SWIPE
OUT OF CONTROL
LEFT TURN
ANGLE
NON-COLLISION

WEATHER
C = Clear
CLDY = Cloudy
F = Fog
S = Snow
SL = Sleet

PAVEMENT
D = Dry
W = Wet
S = Snow
I = Icy

DATE
Mo - Day - Yr.
TIME
0 - 2400 Hrs

EXAMPLE
DATE 2/22/84 1600 TIME
WEATHER C-D DAY LIGHT
PAVEMENT

STOP 30"x30"
Amber Delineators
Steel Guard Rail
4%
9/25/86 2000
RW Nite
Amber Delineators
30"x30"
STOP
0.4%
4%
MPH 10
18"x18"
30"x30"
STOP
30"x30"
Parking Area
8/13/85 1000
Cldy W Day
Gravel
2ND STREET NORTH
12/2/85 1205
C1 Day
E. N.
8TH AVE.
75%
26'
1/9/85 1355
C1 Day
2.3%
11/14/88 1445
S1 Day
10/31/88 2351
CD Nite
.75%
11/4/88 1725
CD Day
1 ST. STREET NORTH
26'
Gravel
FLAT
28'
7TH AVENUE NORTH
STOP
24"x48"
30"x30"
Sign & Post Knocked Down
N
Approx. Scale 1"=10'

Site 1
Existing Conditions &
Collision Diagram
Figure 1A

Recommended Improvements

The major problem at this site is a combination of limited sight distance and excessive vehicle speeds. Unfortunately, the sight-distance problem is caused by a building located on the northeast corner of the intersection of Eighth Avenue and First Street, which cannot be easily removed. A ball bank indicator was used to determine that 10 mph is the maximum safe speed for this site. Motorists require additional information and warning of the conditions at this location.

The following recommendations address the problems and deficiencies at this site:

List of Improvements	Estimated Cost
• Reinstall the stop sign (R1-1, 30"x30") that has been knocked down on the west approach on First Street.	$ 75.00
• Reset the large directional arrow (W1-6, 24"x48") to a mounting height of 5'.	75.00
• Install a large directional arrow (W1-6, 24"x48") for traffic approaching the site from the east. Locate the sign adjacent to the existing directional arrow.	140.00
• Install a reverse turn sign (W1-3, 30"x30") and a 10 mph advisory speed plate (W13-1, 18"x18") 200' east of the site on First Street.	180.00
• Install an "Icy Road" warning sign (W8-8, 30"x30") on Eighth Avenue at the beginning of the curve as shown on Figure 1B. A similar sign should be installed on First Street approximately 400' east of the site. Both signs should be hinged for seasonal use.	300.00
• Remove the existing amber reflectors on the outside of the curve on Eighth Avenue and install white reflectors in their place.	300.00
• Install yellow double solid centerline striping throughout the site.	350.00
• Resurface with a chip seal application every 3 or 4 years in an effort to maximize the skid resistance of the pavement. (No Cost Provided)	
• Consider this site as a high priority for snow removal and sanding operations. (No Cost Provided)	
Total Improvement Costs:	**$1,420.00**
Benefit/Cost Ratio:	**6.80**
• Long-Term Improvement: Reconstruct both curves at this site with a superelevation of 2%. The curve on the corner of Eighth Avenue and First Street should be widened to 30'.	$25,000.00

Hazard Index Calculation Form

Site 1: First Ave. N. & Eighth Ave. N.

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	1.75	acc/yr	35	x	0.164	=	5.74
Accident Rate	4.16	acc/MVE	59	x	0.225	=	13.28
Accident Severity	3,543	dollars	42	x	0.191	=	8.02
Volume/Capacity Ratio	0.19		36	x	0.082	=	2.95
Sight Distance Ratio	0.56	(wt. avg.)	93	x	0.074	=	6.88
Driver Expectancy	3.33	(wt. avg.)	56	x	0.149	=	7.84
Information System Deficiencies	3.0	(wt. avg.)	50	x	0.115	=	5.75

Hazard Index:	50.46
Cost of Recommended Improvements:	$1,420.00
Cost Factor:	99

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(50.46 x .75) + (99 x .25) = 62.60

Replace the Amber Reflectors With White Reflectors.

STOP 30"x30"

Amber Delineators

Steel Guard Rail

Amber Delineators

30"x30"

STOP

10 MPH 18"x18"

30"x30"

ICY ROAD

Install W8-8, 30"x30"

LONG TERM IMPROVEMENT
Reconstruct Curve with A
2% Superelevation

Gravel

2ND STREET NORTH

Parking Area

Install Yellow Double Solid Centerline

8TH AVE. N.

Install W1-3, 30"x30"
W13-1, 18"x18"

LONG TERM IMPROVEMENT
Reconstruct Curve 30' Wide with
2% Superelevation

10 M.P.H.

ICY ROAD

Install W8-8, 30"x30"

Reset to 5' Mounting Height
W1-6, 24"x48"

1ST. STREET NORTH

Gravel

STOP

30"x30"

7TH AVENUE NORTH

Reinstall Stop Sign R1-1

STOP 30"x30"
Sign & Post Knocked Down

24"x48"

Install W1-6, 24"x48"

N

Approx. Scale 1"= 70'

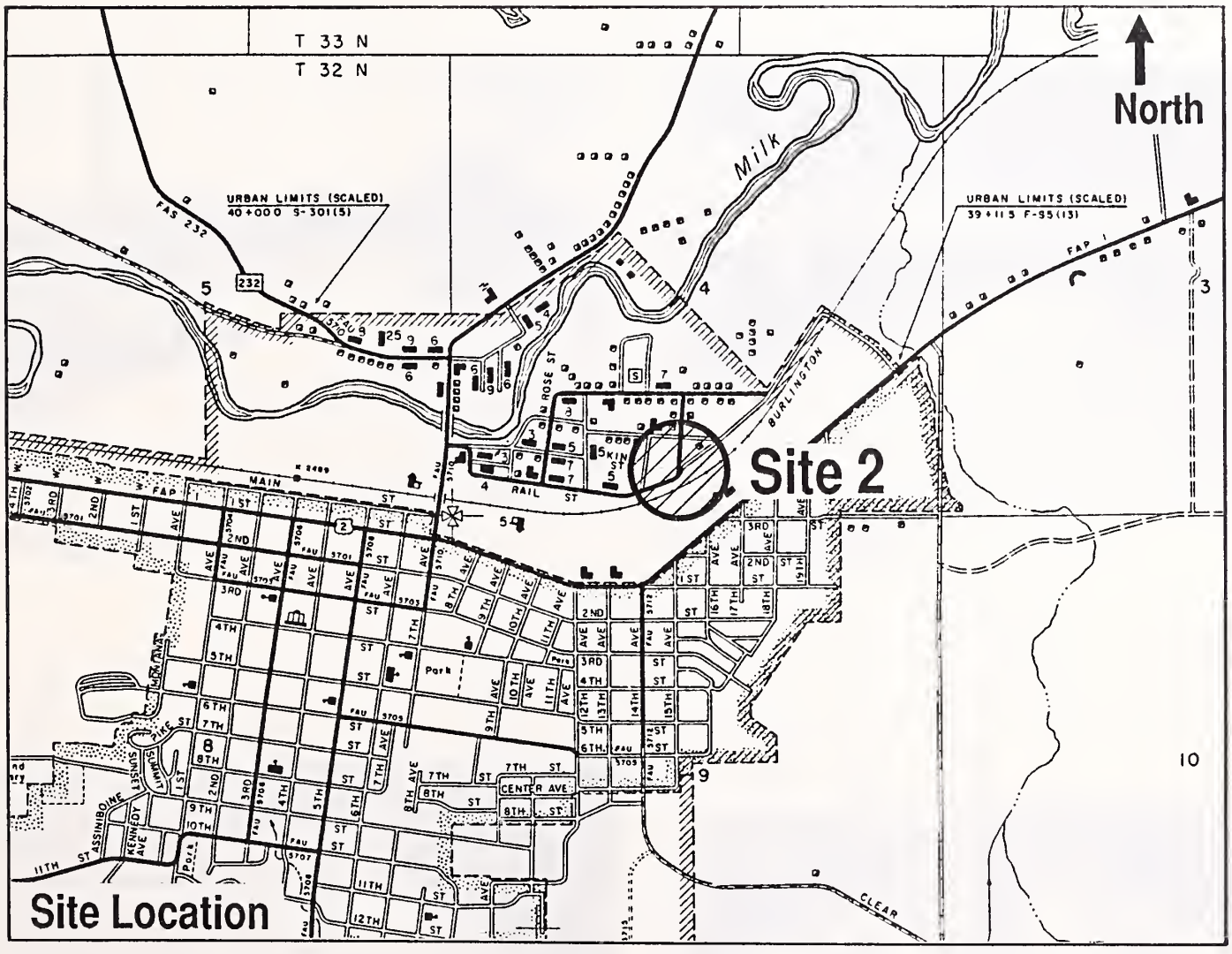
Site 1
Recommended Improvements
Figure 1B

Site 2

Site 2
Existing Conditions

Site 2 is located in northeast Havre at the "T" intersection of First Street North and Thirteenth Avenue North (see map below). First Street runs east to west, roughly parallel to the Burlington Northern (BN) Railroad tracks. Thirteenth Avenue, an 18-foot-wide paved road joins First Street from the north to form a "T" intersection. First Street has a paved surface 23-feet wide west of the intersection which changes to a 25-foot-wide gravel surface east of the intersection. A change in the alignment of First Street at the intersection prevents west-approaching drivers from seeing its eastern extension until they are in the intersection. Site geometrics are shown in Figure 2A.

The entire site is basically flat and free of sight-distance obstructions. There is no traffic control signing at the intersection nor pavement markings on any of the approaches.



Site Photographs

Photograph 1: This photo shows the awkward intersection geometrics as viewed from the west approach on First Street North.

Photograph 2: There is no intersection signing nor pavement markings at this site. This view from the west shows the change in alignment in First Street North at the intersection.

Photograph 3: Thirteenth Avenue is an 18-foot-wide paved road and intersects First Street from the north. The Burlington Northern tracks border the intersection to the south.

Photograph 4: The east approach to the intersection has a 23-foot-wide gravel surface. There are no sight distance problems at this site since the adjacent land is flat and free of structures and tall vegetation.

Photograph 1

Photograph 2

Photograph 3

Photograph 4

Accident History

One accident occurred at this site during the four-year study period. It took place at 12:30 a.m. and involved two vehicles. Both vehicles, eastbound on First Street North, were approaching the intersection of Thirteenth Avenue North. The trailing vehicle attempted to pass the lead vehicle and sideswiped it in the process. The driver of the passing vehicle had been drinking and was cited for driving under the influence. All three occupants in the passing vehicle were injured in the accident. Although it was night, the street was illuminated by street lights. The weather was clear and the pavement dry at the time of the accident.

According to the County Road Superintendent, a fatality accident occurred at this location since the end of the 4-year study period used for this report. The accident involved an eastbound motorist who missed the curve at the intersection and left the roadway.

ACCIDENT DATA

SITE 2: First St. N. & Thirteenth Ave. N. ACCIDENT PERIOD 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
			1

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
				1		

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
								1			

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
																							1

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
	1		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
1				

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
1			

NO. OF ACCIDENTS BY ACCIDENT TYPE

Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
					1				

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
	1							

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)				1 (3)	1 (3)
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.					

ESTIMATED AVERAGE DAILY TRAFFIC

270 VPD

410 VPD

140 VPD

PEAK HOUR TURNING MOVEMENTS

11 0

14 0

4 9

4:45 – 5:45 7/26/89

Vocont Lot

Vacont Lot

Vacont Lot

Tip It Bar

13TH AVENUE NORTH FLAT

IST. ST. N

13TH AVE. N

18'

1%

23'

IST. STREET NORTH

7.5% Super

9/5/88 0030

CD Nite

8' Chain Link Fence

B.N. Shop Bldg.

Gravel

25'

FLAT

B.N.R.R. NO TRESPASSING

Burlington Northern Railroad Yard

SYMBOLS
- VEHICLE PATH
- PEDESTRIAN PATH
- BACKING VEHICLE
- PARKED VEHICLE
- FIXED OBJECT
- FATAL ACCIDENT
- INJURY ACCIDENT (No. Injured)

COLLISION TYPES
- REAR END
- HEAD ON
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- ANGLE
- NON-COLLISION

WEATHER: C = Clear; CLDY = Cloudy; F = Fog; S = Snow; SL = Sleet

PAVEMENT: D = Dry; W = Wet; S = Snow; I = Ice

DATE: Mo - Day - Yr

TIME: 0 - 2400 Hrs.

EXAMPLE: DATE 2/22/84 1600 TIME; WEATHER C D DAY LIGHT; PAVEMENT

Approx. Scale 1"= 100'

Site 2
Existing Conditions & Collision Diagram
Figure 2A

Recommended Improvements

Although no obstructions limit sight distance at this site, the location and alignment of the intersection are difficult to identify. Currently, there are no warning signs or other forms of guidance. A ball bank indicator was used to determine that 20 mph is the maximum safe speed for the curve at the intersection. The major traffic flow is between the west and north legs of the intersection; therefore, it is desirable to control the lowest volume approach, from the east, with a yield sign.

The following recommendations address problems and deficiencies at this site:

List of Improvements	Estimated Cost
• Install a "Turn" warning sign (W1-1, 30"x30") along with a 20 mph advisory speed plate (W13-1, 18"x18") on the west approach on First Street and on the north approach on Thirteenth Avenue. Locate the signs approxmately 200' from the intersection.	$360.00
• Install 2 large directional arrows (W1-6, 24"x48") on the south side of the intersection. Place one sign facing the west approach and one facing the north approach (see Figure 2B).	280.00
• Install a yield sign (R1-2, 36"x36"x36") on the east approach	140.00
• Relocate the telephone pole that is immediately east of the intersection. (No Cost Provided)	
Total Improvement Costs:	**$780.00**
Benefit/Cost Ratio:	**7.63**

Hazard Index Calculation Form

Site 2: First St. N. & Thirteenth Ave. N.

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	0.25	acc/yr	10	x	0.164	=	1.64
Accident Rate	1.74	acc/MVE	28	x	0.225	=	6.30
Accident Severity	2,500	dollars	35	x	0.191	=	6.69
Volume/Capacity Ratio	0.05		17	x	0.082	=	1.39
Sight Distance Ratio	3.33	(wt. avg.)	0	x	0.074	=	0.00
Driver Expectancy	2.33	(wt. avg.)	39	x	0.149	=	5.46
Information System Deficiencies	4.00	(wt. avg.)	67	x	0.115	=	7.71
		Hazard Index:					29.19
		Cost of Recommended Improvements:					$780.00
		Cost Factor:					99

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(29.19 x .75) + (99 x .25) = 46.64

Install W1-1, 30"x30",
W13-1, 18"x18"

20 M.P.H.

Vacant Lot

Vacant Lot

Tip It Bar

13TH AVENUE NORTH

1ST. ST. N.

13TH AVE. N

Vacant Lot

8'Chain Link
Fence

1ST. STREET NORTH

B.N. Shop Bldg.

Gravel

B.N.R.R.
NO
TRESPASSING

Relocate
Telephone
Pole

YIELD

Install R1-2,
36"x36"x36"

Burlington Northern Railroad Yard

20
M.P.H.

Install W1-1, 30"x30",
W13-1, 18"x18"

Install W1-6,24"x48"

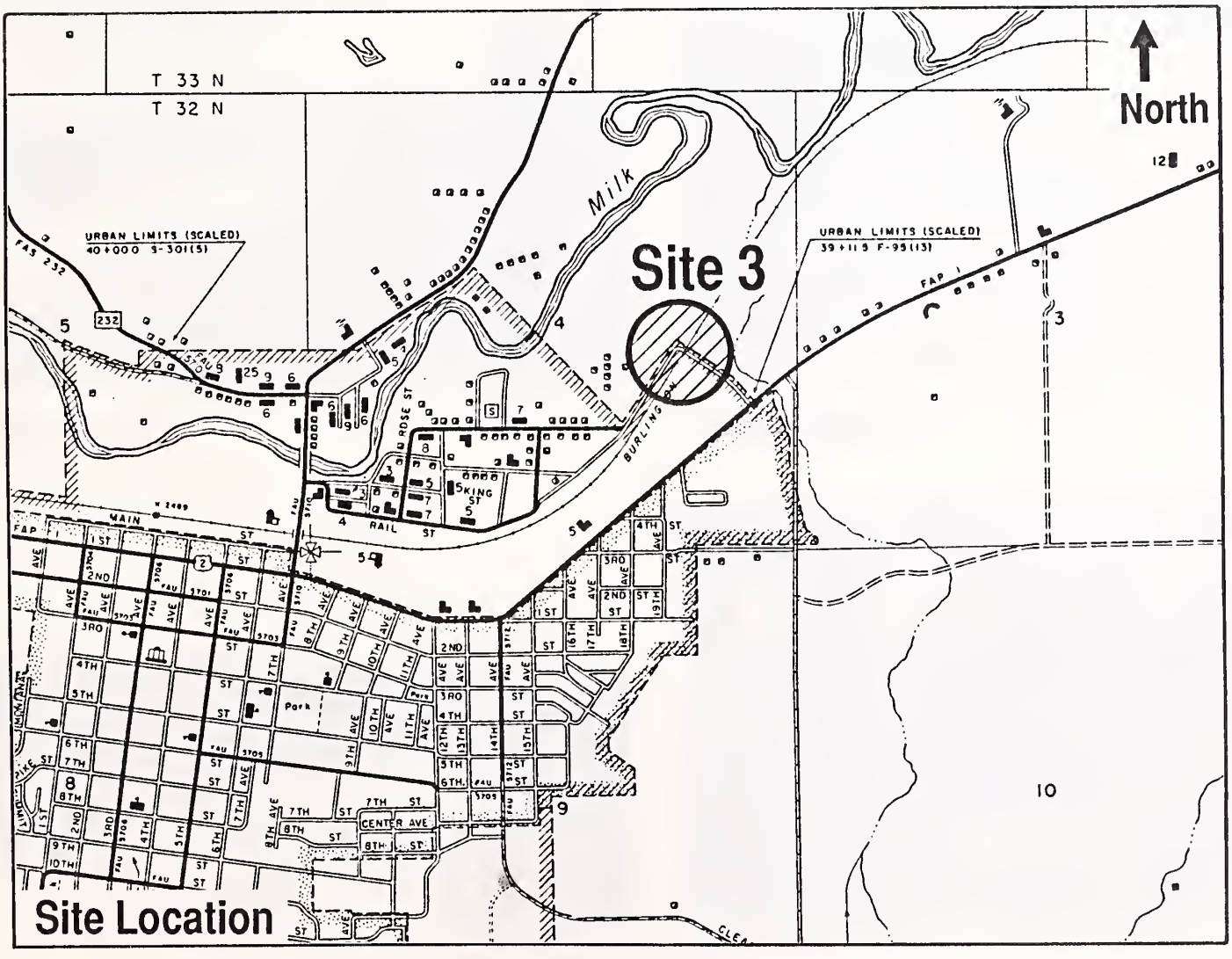
Approx. Scale 1"= 100'

Site 2
Recommended Improvements
Figure 2B

Site 3

Site 3
Existing Conditions

Site 3 (see map below) is located where 22nd Avenue crosses the BN Railroad northeast of Havre. This 30-foot-wide gravel road connects U.S. Highway 2 with the residential community north of the tracks. It also provides access for three major businesses: a grain elevator on the south side of the tracks, an agriculture fertilizer center northwest of the site, and a gravel pit located northeast of the site. The railroad crossing consists of five sets of tracks equipped with automatic gate arms and flashing lights, which were functioning properly at the time of the site investigation. The only railroad-crossing warning sign at this site was on the northwest approach. Posts for the warning signs on the south and northeast approaches were in place, but the signs were missing. Because the elevation of the railroad tracks is 10 feet higher than the surrounding ground, the road slopes up to the tracks at approximately 4% on both sides of the crossing. Sight distance on both approaches is limited due to the elevation difference. A "Y" intersection just north of the railroad crossing provides access on the right to the Riverside Mobile Park and the gravel pit. The left fork continues around a curve to the west and provides access to the North Havre residential area. Details of the site layout are shown in Figure 3A.



Site Photographs

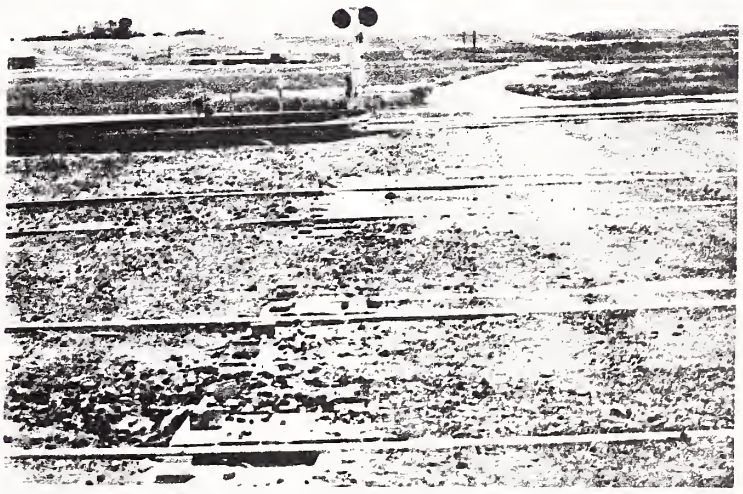
Photograph 1: This railroad crossing sign on the northwest approach was the only sign found standing at this site. The posts for railroad crossing signs on the northeast and south approaches were found, but the signs were missing.

Photograph 2: Yellow reflectors have been attached to the wooden crossing platform in an effort to delineate the edge of the roadway.

Photograph 3: Numerous large trucks use this crossing when traveling to and from the gravel pit located northeast of the site. The crossing warning lights and gate were functioning correctly at the time of the site visit.

Photograph 4: This curve warning sign was lying in the grass on the side of the northeast approach to the crossing.

Photograph 1



Photograph 2

Photograph 3

Photograph 4

Accident History

During the four-year study period, 11 accident occurred at this site. In eight accidents, a single southbound vehicle ran off the east side of the road at the railroad crossing. A head-on collision involving two vehicles also took place at the crossing. The roadway north of the crossing was the location of two single-vehicle accidents. In both cases, the driver lost control of the vehicle and slid off the road.

All of the accidents occurred at night; and in nine cases, weather conditions were clear and dry. Alcohol was involved in six accidents. A total of ten people were injured in six accidents with the other five accidents resulting in property damage only. The collision diagram is included in Figure 3A. A detailed breakdown of the accident statistics are presented below.

ACCIDENT DATA

SITE 3: 22nd Ave. N. & BN RR Crossing **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
	2	6	3

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
3		1	2	1	2	2

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		3	1		1			1	1		4

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1		1													1		1	2		2	1	2

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
	11		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
9	1	1		

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
10	1		

NO. OF ACCIDENTS BY ACCIDENT TYPE

Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
		9				1	1		

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
4	6		1					

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)		2 (4)	2 (4)	2 (2)	6 (10)
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.			4	1	5

To Gravel Pit

Riverside Mobil Home Park

Grain Elevator

Vacant Lot

BURLINGTON NORTHERN RAILROAD

Gravel Drive

24"x 30"
SPEED LIMIT 25

Orange & White Reflectorized Panels (Typ.)

3' CMP

Steel Sign Post (No Sign)

22ND AVENUE NE

STOP
30"x30"

U.S. 2

9/28/86	0345	CD	Nite	Inj.(1)
3/15/87	0005	CD	Nite	
12/6/87	1710	CD	Nite	Inj.(2)
12/24/87	2248	CD	Nite	Inj.(2)
12/30/87	1855	SS	Nite	
3/11/88	2305	CD	Nite	Inj.(1)
3/29/88	2000	CW	Nite	Inj.(1)
10/7/88	2045	CD	Nite	

Railroad Elec. Enclosure

F.H.

Steel Sign Post (No Sign)

6' Depression

30"x 30" (Sign & Post Knocked Down)

4/4/87 2220 CD Nite

6/7/87 0215 CD Nite

Railroad Crossing Gates

36" Dia.

12/31/86 2353 CD Nite

Private Drive

Dirt Trail

Vacant Lot

AG Fertilizer Center

FLAT

5%
8%
4%
4%
1%
30'
28'
8'

ESTIMATED AVERAGE DAILY TRAFFIC

200 VPD
400 VPD
340 VPD

PEAK HOUR TURNING MOVEMENTS

4
0
1
9
3
21

4:45–5:45 7/25/89

SYMBOLS
- VEHICLE PATH
- PEDESTRIAN PATH
- BACKING VEHICLE
- PARKED VEHICLE
- FIXED OBJECT
- FATAL ACCIDENT
- INJURY ACCIDENT (No Injured)

COLLISION TYPES
- REAR END
- HEAD ON
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- ANGLE
- NON-COLLISION

WEATHER: C = Clear; CLOY = Cloudy; F = Fog; S = Snow; SL = Sleet

PAVEMENT: D = Dry; W = Wet; S = Snow; I = Icy

DATE: Mo. - Day - Yr

TIME: 0 - 2400 Hrs

EXAMPLE: DATE 2/22/84 1500 TIME; WEATHER C D DAY LIGHT; PAVEMENT

Approx. Scale 1" = 100'

Site 3
Existing Conditions & Collision Diagram
Figure 3A

Recommended Improvements

The major problem at this site is the north approach to the railroad crossing. It is on a 4% grade, which levels out just before the first set of tracks. The crossing platform is essentially level. When a vehicle approaches the crossing at night, its headlights point up in the air making it difficult to see the crossing. The situation is compounded by an alignment change in 22nd Avenue at this location. By the time the vehicle levels out and its headlights are shining on the ground again, the motorist has driven off the east side of the crossing platform. In an effort to correct this problem, the County has installed ground-mounted reflectors along the east side of the crossing platform. Unfortunately, they are not visible until it is too late to take corrective action. Accident records indicate the problem exists only at night; and field observations of motorists at the site tend to confirm this. There was no indication motorists approaching the crossing during the day had any problem identifying the roadway alignment. The south approach to the crossing has a similar grade, but there is no evidence of any problem from that direction.

The following recommendations address problems and deficiencies at the site:

List of Improvements	Estimated Cost
• Replace the missing "Railroad Crossing" advance warning signs (W10-1, 36" dia.) on the south and northeast approaches.	$ 200.00
• Control traffic approaching from the northeast by installing a yield sign (R1-2, 36"x36"x36") at the "Y" intersection north of the tracks.	140.00
• Relocate the "Curve" warning sign (W1-2, 30"x30") on the north approach to a point 300' from the railroad crossing.	100.00
• Replace the existing orange and white panels that mark the culvert crossing on the south approach with black and yellow object markers (OM-3, 12"x36").	520.00
• Remove the trees and brush located on the north side of the intersection at this site.	500.00
• Relocate the "Railroad Crossing" warning sign (W10-1, 36" dia.) on the northwest approach to a point approximately 200' from the crossing.	100.00
• Reconstruct the north approach by making it 50' long and level with the grade of the crossing.	5,000.00
Total Improvement Costs.	**$ 6,560.00**
Benefit/Cost Ratio:	**19.43**

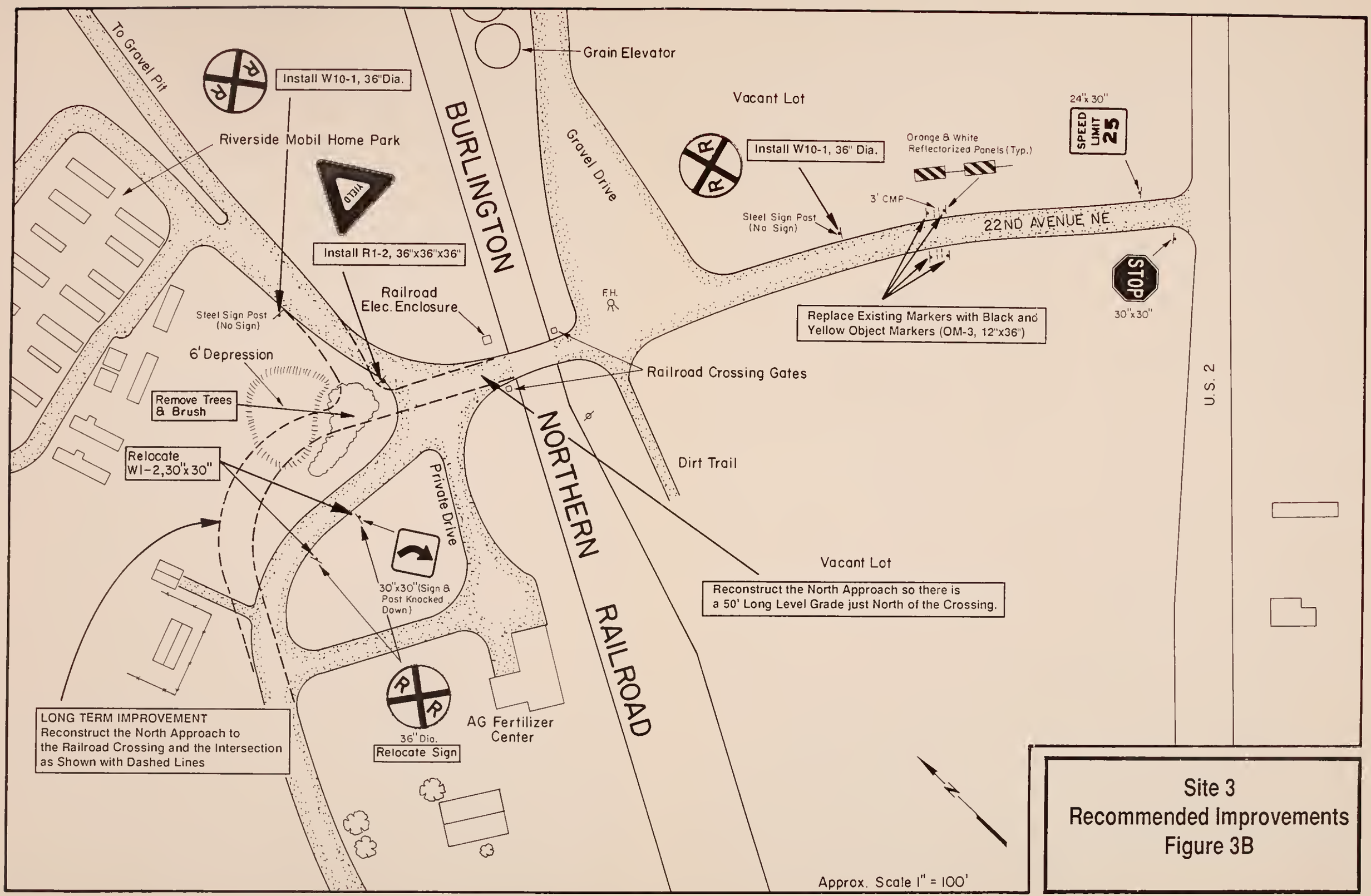
- **Long-TermImprovement**: The long-term improvement at this site involves reconstructing the north approach so it is perpendicular to the tracks and at least 50' long. The alignment of 22nd Avenue should be extended straight from the tracks for approximately 200' and then curved to the west to connect with the existing road system. The side approach from the gravel pit and the mobile home park should join 22nd Avenue at a 90° angle to form a standard "T" intersection. This side road approach should be controlled with a yield sign. The general configuration of the proposed changes is shown in Figure 3B. $30,000.00

Hazard Index Calculation Form

Site 3: 22nd Ave. N. & BN RR Crossing

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	2.75	acc/yr	43	x	0.164	=	7.05
Accident Rate	16.52	acc/MVE	100	x	0.225	=	22.50
Accident Severity	5,564	dollars	49	x	0.191	=	9.36
Volume/Capacity Ratio	0.09		25	x	0.082	=	2.05
Sight Distance Ratio	0.56	(wt. avg.)	93	x	0.074	=	6.88
Driver Expectancy	4.00	(wt. avg.)	67	x	0.149	=	9.38
Information System Deficiencies	3.33	(wt. avg.)	56	x	0.115	=	6.44
	Hazard Index:						63.21
	Cost of Recommended Improvements:						$6,560.00
	Cost Factor:						85

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(63.21 x .75) + (85 x .25) = 68.66

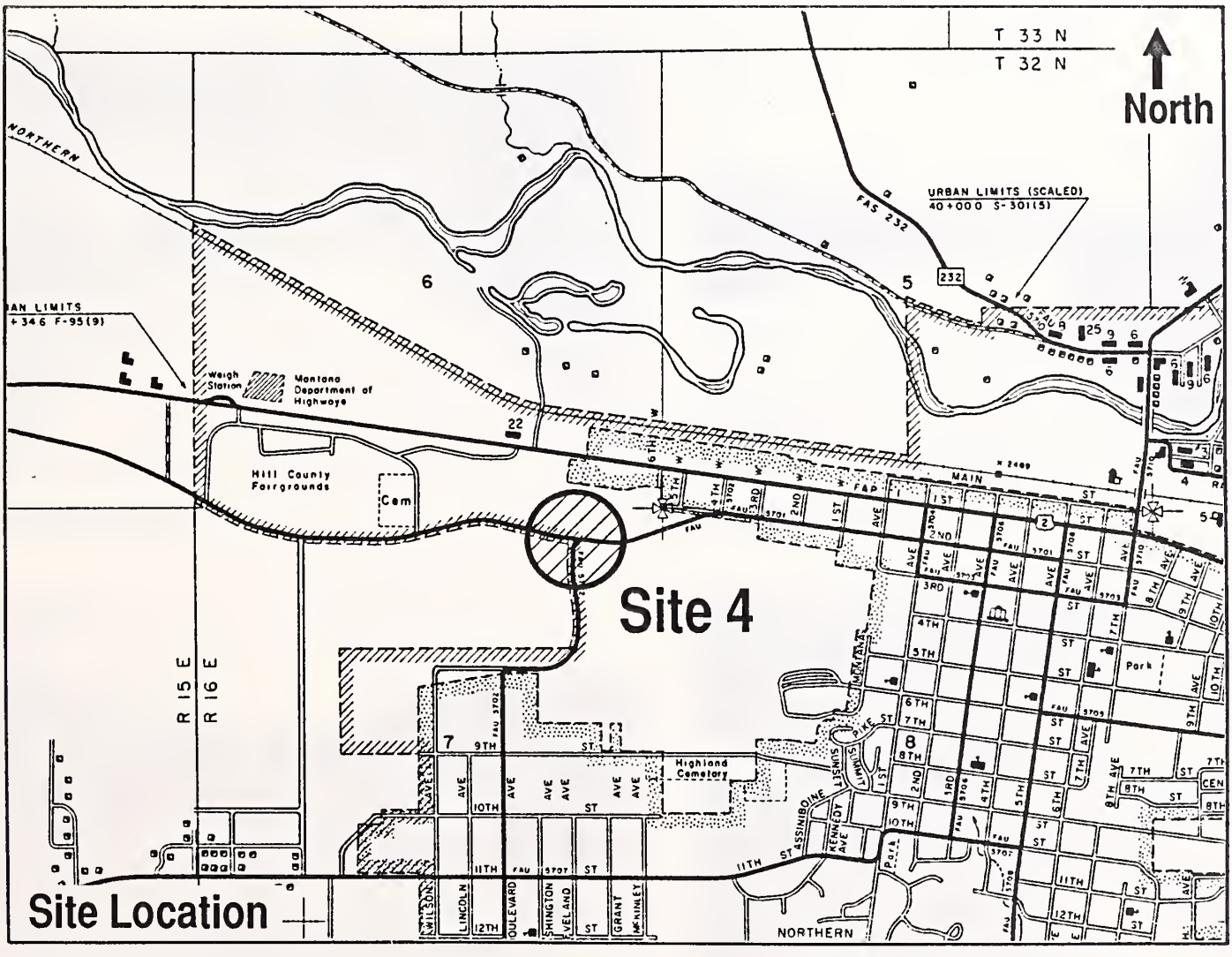


Site 3
Recommended Improvements
Figure 3B

Site 4

Site 4
Existing Conditions

This site consists of a three-way intersection formed by the junction of Second Street West (Old U.S. Highway 2) and County Road 651 on the west side of Havre (see map below). Second Street has an east-west alignment with County Road 651 intersecting it on the south. Both roads are paved and approximately 28 feet wide. Second Street slopes gently to the east at approximately 3%. County Road 651 traverses a steep hill with a grade of 6%, then flattens to 4% near the intersection. Traffic control at the site consists of a yield sign on County Road 651. Second Street has a double solid yellow centerline and white edge line stripes and a posted speed limit of 35 miles per hour (mph). County Road 651 has only a double solid centerline and a posted speed limit of 25 mph. The Sagebrush Athletic Club is located on the southwest corner of the intersection. This building and vehicles in its parking lot obstruct sight distance at the intersection. Figure 4A details the layout of this site.



Site Photographs

Photograph 1: The speed limit changes from 45 to 35 mph as you approach the site from the west. Second Street slopes toward the east at a rate of approximately 3%.

Photograph 2: The driver's view of the intersection is unobstructed when approaching from the east. Second Street is a 28-foot-wide paved road with a yellow, double solid centerline and white edgeline striping.

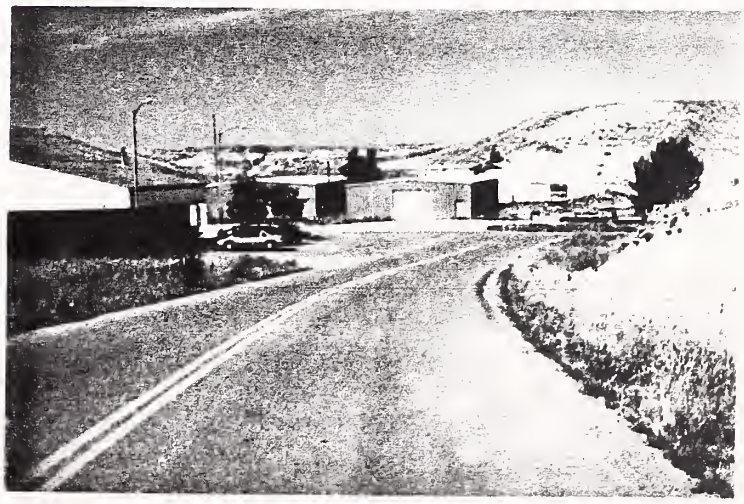
Photograph 3: County Road 651 winds down the side of a hill with road grades ranging from 4 to 6%. The Athletic Club parking lot is immediately adjacent to the intersection on the southwest corner.

Photograph 4: The Athletic Club, shown on the left in this picture of the intersection, blocks the driver's view of traffic approaching the intersection from the west.

Photograph 1

Photograph 2

Photograph 3



Photograph 4

Accident History

Site 4 was the scene of twelve accidents during the study period. Nine involved an angle collision of two vehicles. Most of these accidents were caused by a driver failing to yield the right of way. Three cases involved single-vehicle collisions. One incident resulted when a northbound vehicle slid through the intersection and struck a car parked at the edge of the roadway. The other single-vehicle accidents were caused by the driver loosing control of the vehicle and going off the roadway. Eleven of the accidents at this site occurred during the hours of 10:00 a.m. and 5:00 p.m. Conditions were clear and dry in seven cases, while icy roads contributed to the other five accidents. Six of the accidents resulted in injuries to ten people. Additional information concerning the accident history at this site is presented below and in the collision diagram shown in Figure 4A.

ACCIDENT DATA

SITE 4: Second St. W. & County Rd. 651 **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
3	4	1	4

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
	1	4	3	1	2	1

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
3		1			2		1			3	2

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
									1	3		3			2	2					1		

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
10	2		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
7			5	

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
9		3	

NO. OF ACCIDENTS BY ACCIDENT TYPE

Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
9		2				1			

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
3	1	1		6			1	

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)	3 (5)	1 (2)	1 (2)	1 (1)	6 (10)
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.		3		3	6

ESTIMATED AVERAGE DAILY TRAFFIC

2830 VPD

3570 VPD — 1680 VPD

PEAK HOUR TURNING MOVEMENTS

98 10

141 — 11

64 — 81

4:30-5:30 7/19/89

COLLISION DIAGRAM

12/24/85 1638 C.D. Day

11/30/85 1710 C.I. Nite

1/29/85 1600 C.D Day

1/14/87 1005 C.I. Day

12/31/86 1050 C.D Day

3/16/88 2230 C.D Nite

6/20/88 1120 C.I. Day

11/14/88 1250 S.I. Day

11/14/88 1305 S.I. Day

6/24/86 1718 C.D. Day

1/30/86 1105 S.I. Day

8/5/86 1255 Cloudy/D. Day

SYMBOLS: VEHICLE PATH; PEDESTRIAN PATH; BACKING VEHICLE; PARKED VEHICLE; FIXED OBJECT; FATAL ACCIDENT; INJURY ACCIDENT; (NO Injuries)

COLLISION TYPES: REAR END; HEAD ON; SIDE SWIPE; OUT OF CONTROL; LEFT TURN; ANGLE; NON COLLISION

WEATHER: C = Clear; CLOY = Cloudy; F = Fog; S = Snow; SL = Sleet

PAVEMENT: D = Dry; W = Wet; S = Snow; I = Icy

DATE: Mo - Day - Yr

TIME: 0 2400 Hrs

EXAMPLE: DATE 2/22/84 1600 TIME; WEATHER C.D. DAY LIGHT; PAVEMENT

-6%

26'

SPEED LIMIT 25

24"x30"

COUNTY ROAD 651

4%

34"x34"x34"

CO. RD. 651

2ND ST. W.

24"CMP

Sagebrush Athletic Club

Drain Grate

24"x36"

SPEED LIMIT 35

SPEED CHECKED BY RADAR

24"x18"

3%

2ND STREET WEST

27'

2.5%

24"x48"

SPEED LIMIT 45

24"x30"

Brown's Warehouse Storage

N

Approx. Scale 1"= 100'

Site 4
Existing Conditions & Collision Diagram
Figure 4A

Recommended Improvements

The Manual on Uniform Traffic Control Devices Handbook outlines a procedure for using stop and yield signs for intersection control. The procedure uses vehicle approach speeds and available sight distance to determine if it is safe to control the side road traffic with a yield sign. According to this procedure, a stop sign would be more appropriate at this location. The intersection warrants a stop sign based on the limited sight distance created by vehicles parked in the Athletic Club parking lot.

The following recommendations address the problems and deficiencies identified at Site 4:

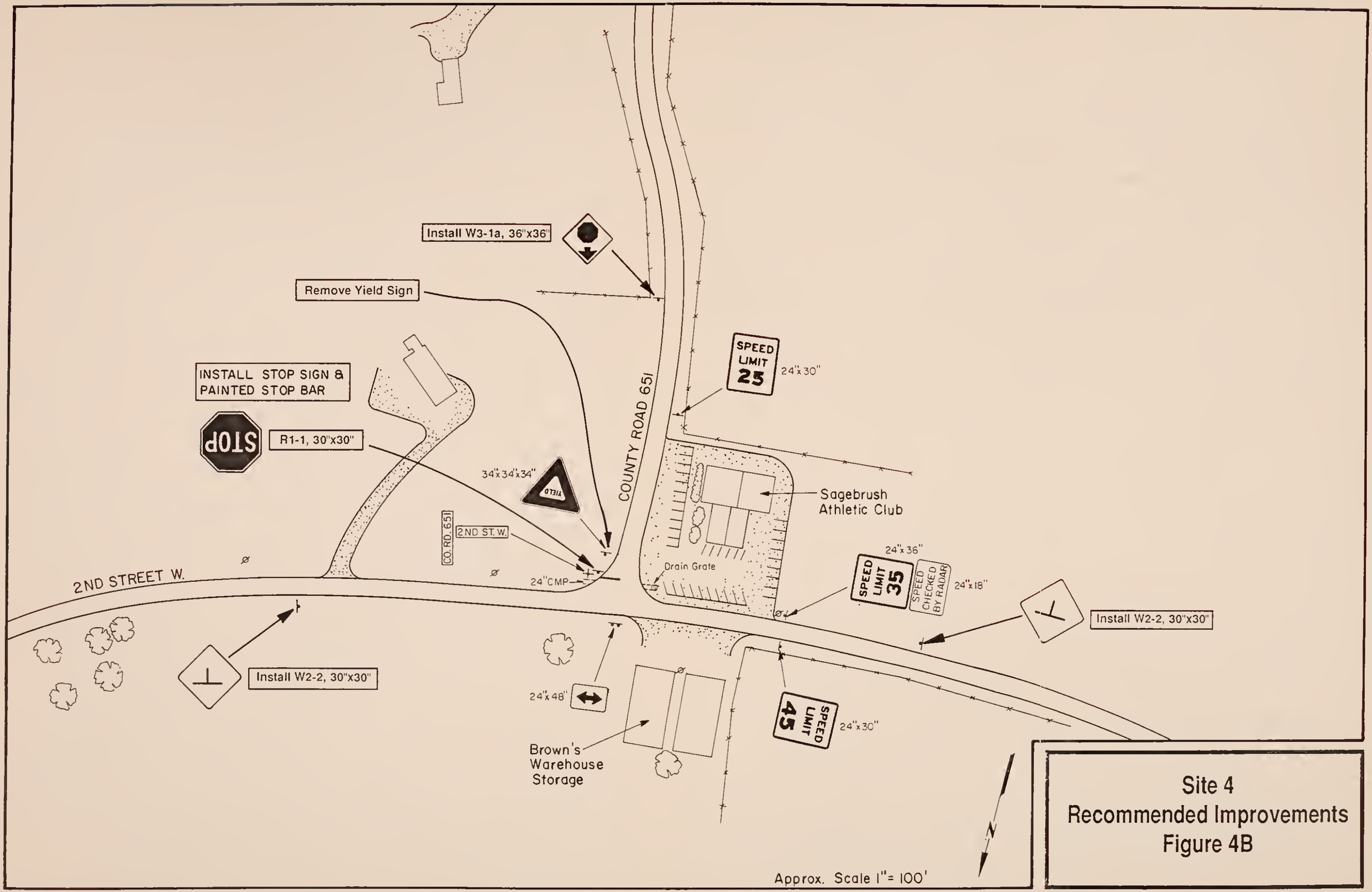
List of Improvements	Estimated Cost
• Remove the existing yield sign on the south approach.	$ 100.00
• Install a stop sign (R1-1, 30"x30") and a painted stop bar on the south approach. The stop sign should be located as close to the intersection as practical.	175.00
• Install a "Stop Ahead" warning sign (W3-1a, 36"x36") 300' south of the intersection on County Road 651.	140.00
• Install "Side Road" warning signs (W2-2, 30"x30") on the east and west approaches 300' from the intersection.	280.00
Total Improvement Cost:	**$ 695.00**
Benefit/Cost Ratio:	**39.11**

Hazard Index Calculation Form

Site 4: Second St. W. & County Rd. 651

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	3.00	acc/yr	45	x	0.164	=	7.38
Accident Rate	2.13	acc/MVE	34	x	0.225	=	7.65
Accident Severity	4,467	dollars	46	x	0.191	=	8.79
Volume/Capacity Ratio	0.75		100	x	0.082	=	8.20
Sight Distance Ratio	0.67	(wt. avg.)	71	x	0.074	=	5.25
Driver Expectancy	2.67	(wt. avg.)	45	x	0.149	=	6.30
Information System Deficiencies	2.33	(wt. avg.)	39	x	0.115	=	4.49
	Hazard Index:						48.06
	Cost of Recommended Improvements:						$695.00
	Cost Factor:						100

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(48.06 x .75) + (100 x .25) = 61.05

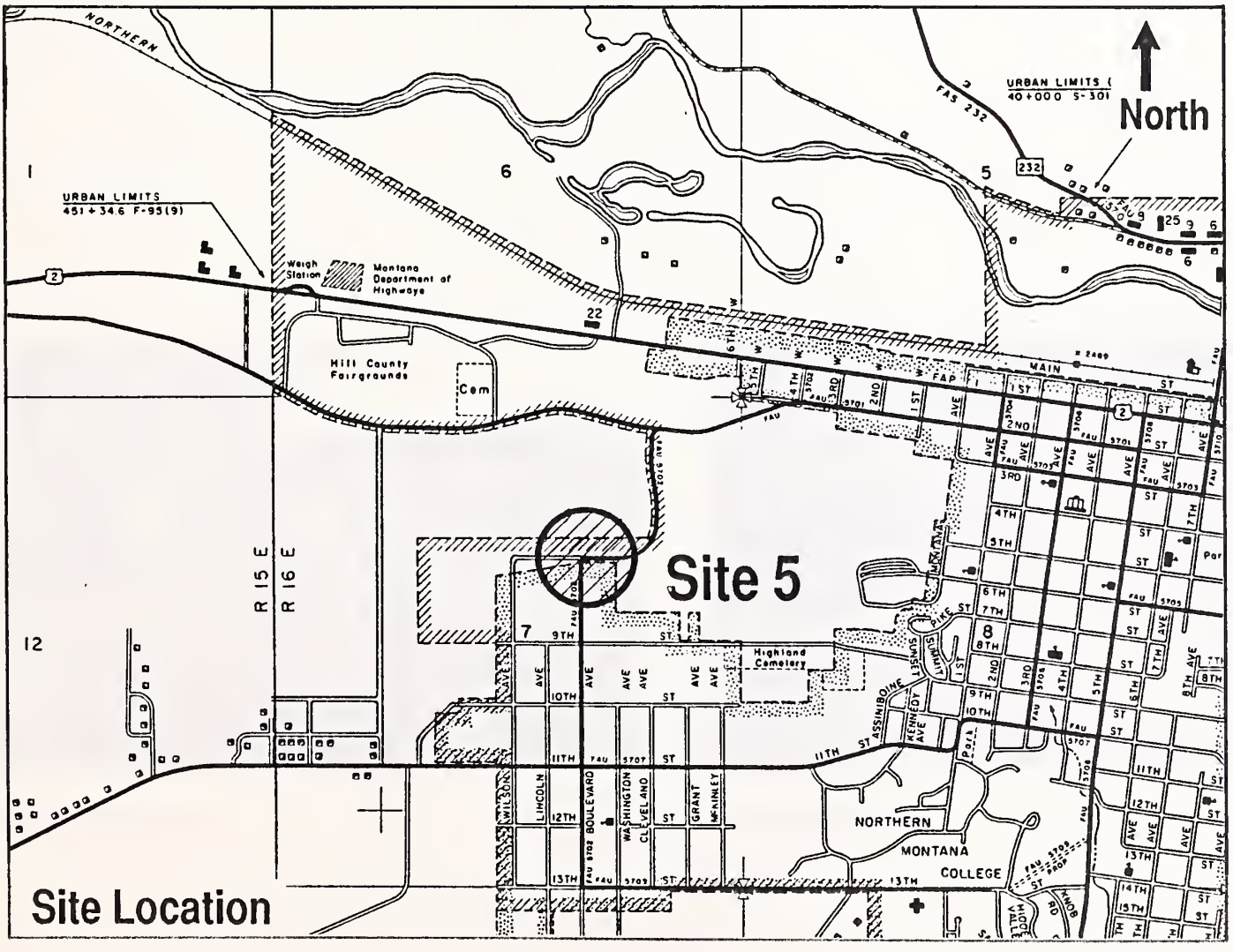


Site 4
Recommended Improvements
Figure 4B

Site 5

Site 5
Existing Conditions

This site is a "T" intersection formed by the junction of Boulevard Avenue and County Road 651 on the west side of Havre. County Road 651, a 26-foot-wide paved roadway, extends east and west through the study area. It slopes toward the east at approximately 5%. Boulevard Avenue intersects County Road 651 from the south at roughly a 90° angle. This portion of Boulevard Avenue is very steep with grades increasing from 8 to 12% as it climbs the hill south of the intersection. A yield sign on the Boulevard Avenue approach provides traffic control at the intersection. Pavement markings within the site include a single solid centerline stripe on Boulevard and a double solid centerline on both approaches on County Road 651. Posted speed limit within the study area is 25 mph on both roads. The area south of the site is predominantly residential. (See Figure 5A for additional site details.) Estimates of traffic volumes at the site indicate that County Road 651 carries 2,830 vehicles per day (VPD) on the portion east of the intersection and only 600 VPD west of the site. Boulevard Avenue carries approximately 1,430 VPD. Turning movement counts indicate that major traffic flow is between the east and south legs of this intersection.



Site Photographs

Photograph 1: The driver's view of this intersection is unobstructed from the west approach on County Road 651. Boulevard Avenue comes down the steep hill on the right and is controlled with a yield sign.

Photograph 2: Motorists approaching the intersection from the east have this view of the site. Over 80% of the vehicles that approach from the east turn left onto Boulevard Avenue.

Photograph 1

Photograph 2

Accident History

The intersection at Site 5 was the scene of nine accidents during the study period. Icy-road conditions were a factor in eight of the accidents. In the case where ice was not involved, the driver of a northbound vehicle on Boulevard Avenue failed to yield the right of way at the intersection and struck an eastbound vehicle. A total of five angle accidents and two rear-end collisions occurred. In three other cases, a northbound vehicle slid through the intersection and struck objects on the north side of the junction. Two objects were disabled vehicles from accidents that happened earlier in the day.The other object was a warning sign. Eight of the nine accidents took place during daylight hours. No one was injured in any of the collisions at this site. Figure 5A shows a collision diagram of the accidents, and the form below contains additional data reflecting the accident history at this intersection.

ACCIDENT DATA

SITE 5: Boulevard Ave. & County Rd. 651 **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
3	4		2

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
	4		2		2	1

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	3		1							3	1

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
							1			1		2		2	2			1					

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
8	1		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
1			8	

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
5		4	

NO. OF ACCIDENTS BY ACCIDENT TYPE

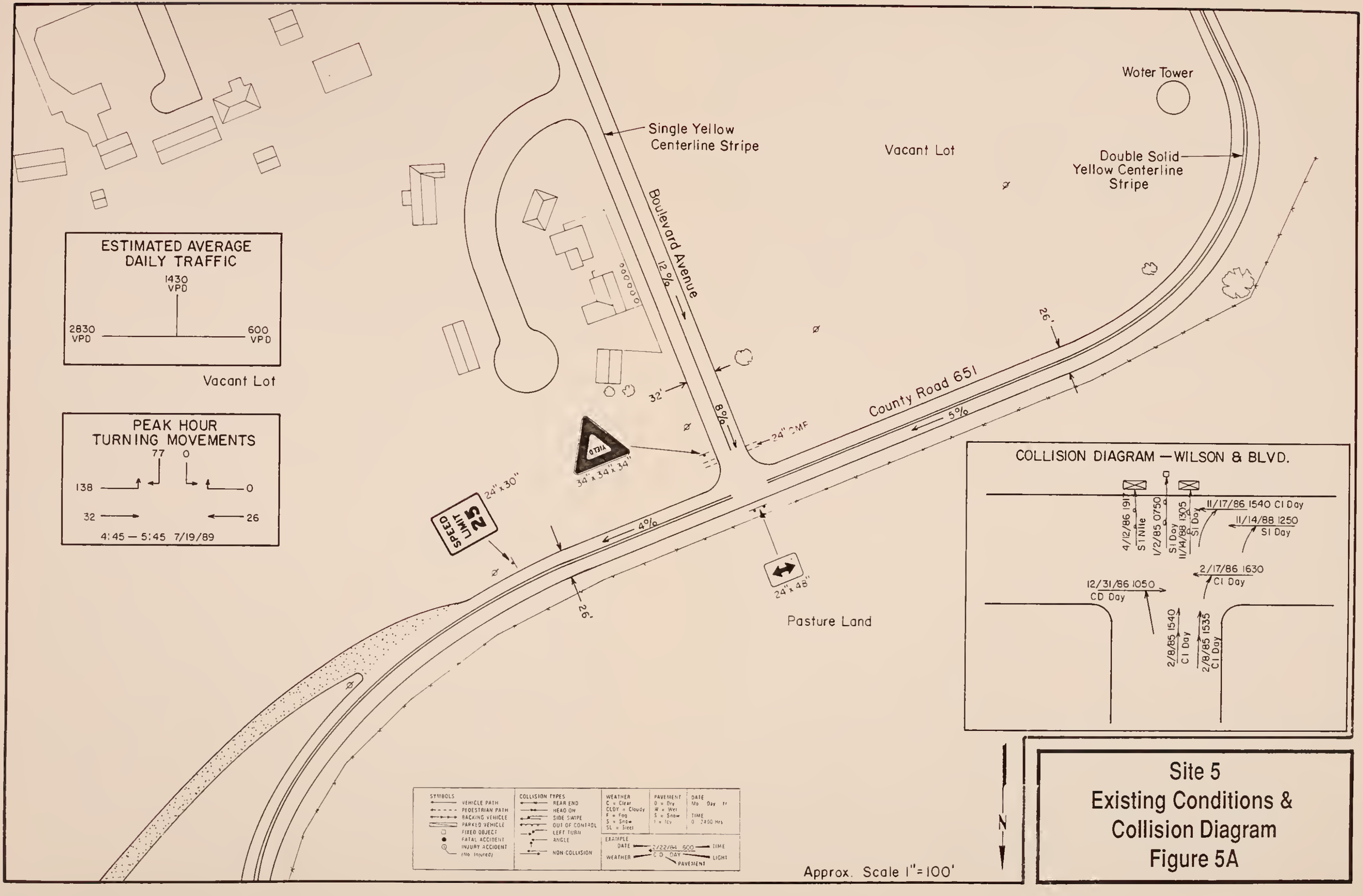
Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
4	2	3							

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
5				4				

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)					
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.	3	4		2	9



Site 5
Existing Conditions & Collision Diagram
Figure 5A

Recommended Improvements

The steep grade on Boulevard is obviously a problem during icy conditions. Other problems also exist at this site. Northbound motorists on Boulevard have a limited view of the intersection due to the crest in the hill. Field observations of traffic at the location revealed that many motorists on Boulevard Avenue don't yield to traffic on County Road 651. In addition, numerous vehicles were observed cutting the inside of the curve when turning left onto Boulevard from the east approach. It is apparent that motorists traveling upgrade are trying to maintain their speed while drivers traveling down the hill are trying to control their vehicle's momentum. This combination is the perfect setup for an angle accident.

A ball bank indicator was used to determine that 15 mph is the maximum safe speed when making a right turn from Boulevard onto County Road 651.

The following recommendations address problems and deficiencies at the site:

List of Improvements	Estimated Cost
• Install an "Icy Road" warning sign (W8-10, 30"x30") 350' south of the intersection. The sign should be hinged so it is not displayed during the summer months.	$ 150.00
• Install a "T" intersection warning sign (W2-4, 30"x30") with a 15 mph advisory speed plate (W13-1, 18"x 18") at the crest of the hill on Boulevard Avenue.	180.00
• Install "Side Road" warning signs (W2-2, 30"x30") on both the east and west intersection approaches. The signs should be located 200' from the intersection.	280.00
• Replace the existing yield sign with an oversized yield sign (R1-2, 48"x48"x48"). The sign should be mounted 9' above the ground for improved visibility.	220.00
• Replace the single yellow centerline on Boulevard Avenue with a double, solid yellow centerline.	200.00
• Resurface the hill on Boulevard Avenue with a chip and seal application on a 3- to 4-year cycle in an effort to provide a consistently high level of skid resistance. (No Cost Provided)	
• Consider this site as a high priority for snow removal and sanding operations. (No Cost Provided)	
Total Improvement Costs:	**$ 1,030.00**
Benefit/Cost Radio:	**1.55**

List of Improvements	Estimated Cost
• **Long-Term Improvement**: It is desirable to minimize the number of turning movements and the amount of delays encountered when traversing any site. The current traffic control at this intersection requires the relatively large approach volume on Boulevard to yield while a much smaller approach volume for the west is given the right-of-way. The current system is appropriate for the existing intersection geometics. The east-south flow of traffic is the prominent movement at this location. If possible, the intersection should be reconstructed so Boulevard angles into County Road 651 producing a through movement between the two streets. The west approach on County Road 651 could then be controlled by a yield sign. In past winters, the County has attempted to close the one-block-long section of Boulevard (which includes the steep hill) during icy conditions. According to County personnel, the barricades were repeatedly moved aside by locals who continue to use the hill. Since closing this portion of roadway during hazardous winter conditions does not appear possible, consideration should be given to reconstructing the hill with a flatter grade. Field observations indicate that a maximum grade of 8% may be attainable. Unfortunately, a signifiant cut would be required which would most likely affect the adjacent property owners.	$150,000.00

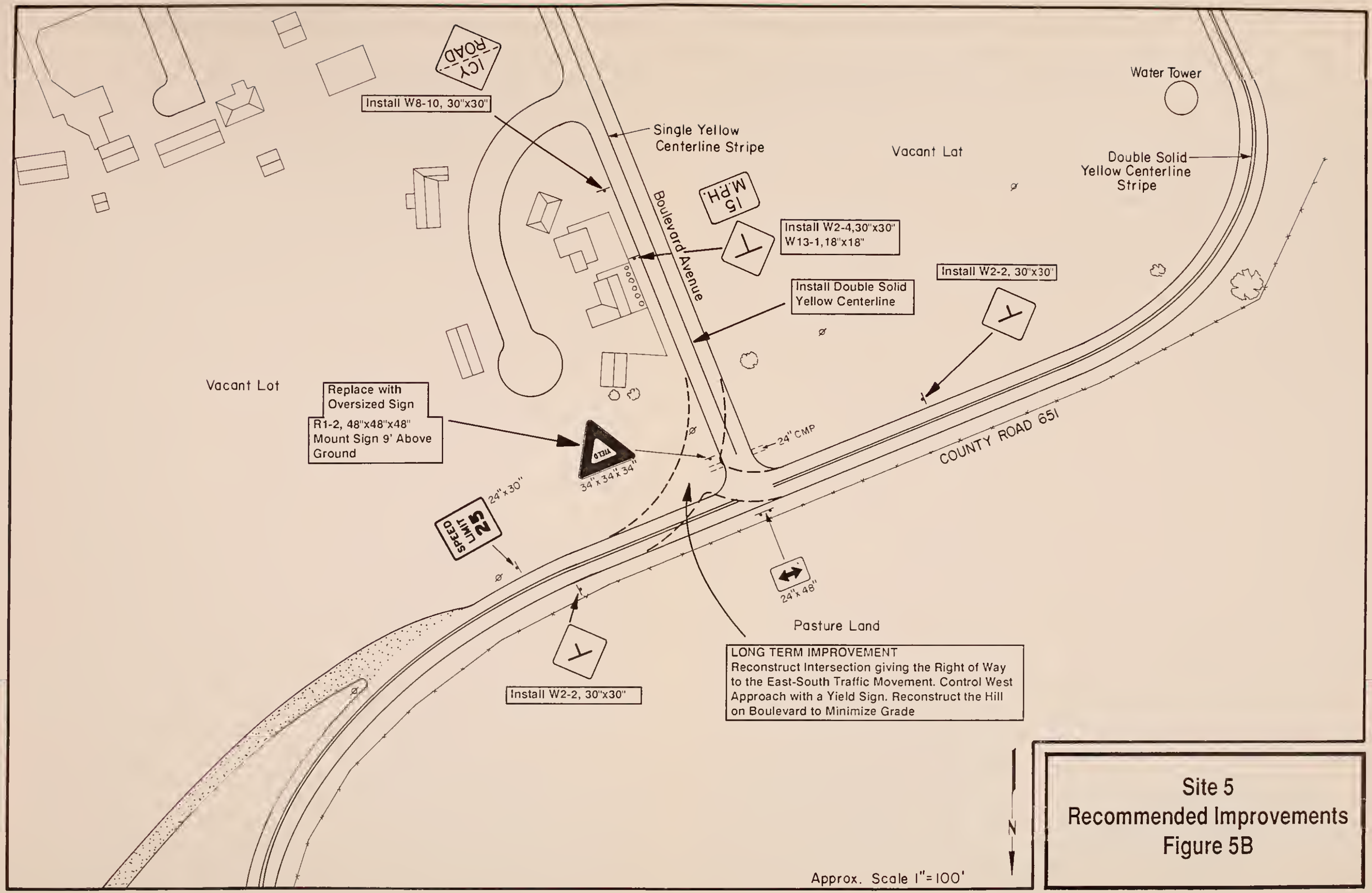
Hazard Index Calculation Form

Site 5: Boulevard Ave. & County Rd. 651

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	2.25	acc/yr	38	x	0.164	=	6.23
Accident Rate	2.64	acc/MVE	40	x	0.225	=	9.00
Accident Severity	4,489	dollars	46	x	0.191	=	8.79
Volume/Capacity Ratio	0.97		100	x	0.082	=	8.20
Sight Distance Ratio	1.50	(wt. avg.)	9	x	0.074	=	0.67
Driver Expectancy	1.33	(wt. avg.)	22	x	0.149	=	3.08
Information System Deficiencies	2.33	(wt. avg.)	39	x	0.115	=	4.49

Hazard Index:	40.46
Cost of Recommended Improvements:	$1,030.00
Cost Factor:	100

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(40.46 x .75) + (100 x .25) = 55.35

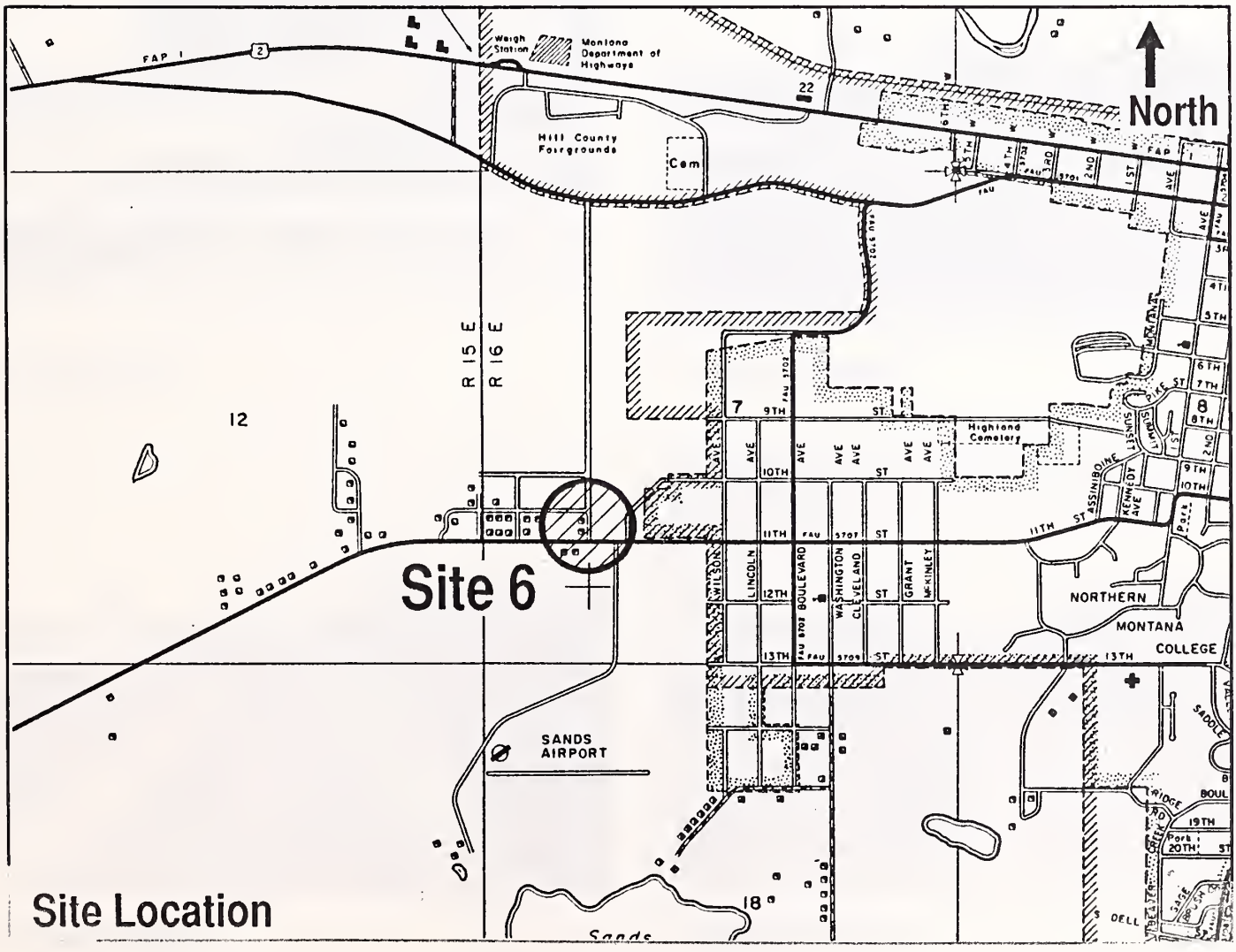


Site 5
Recommended Improvements
Figure 5B

Site 6

Site 6
Existing Conditions

Site 6 consists of the "T" intersection of Eleventh Street and Sixteenth Avenue West on the west side of Havre (see map below). Sixteenth Avenue is a 40-foot-wide paved street with curb and gutter. Eleventh Street has a rural road cross-section with a 22-foot-wide paved surface and shallow drainage ditches on both sides. It is straight and relatively flat east of the site. Beginning 100 feet west of the intersection, Eleventh Street begins to slope down at a grade of 5 to 6%, which limits sight distance at the intersection. Sixteenth Avenue slopes toward the intersection with grades of 4% flattening to 1% at the junction (see Figure 6A for additional details). Sixteenth Avenue is controlled by a stop sign at the intersection. Although no centerline striping exists on Sixteenth Avenue, there are several painted crosswalks, equipped with pedestrian warning signs, within two blocks of the intersection. Both approaches to the Eleventh Avenue intersection have a double solid centerline. The speed limit is posted at 25 mph for both roads within the study area. The Havre Middle School is located on the northeast corner of the intersection and a residential development to the northwest. The area south of Eleventh Street is used for wheat production with the exception of a plumbing supply store and residence immediately adjacent to the road. Traffic volumes were estimated to be 1,500 VPD on Sixteenth Avenue. Approximately 1,830 VPD use Eleventh Street east of the intersection.



Site Photographs

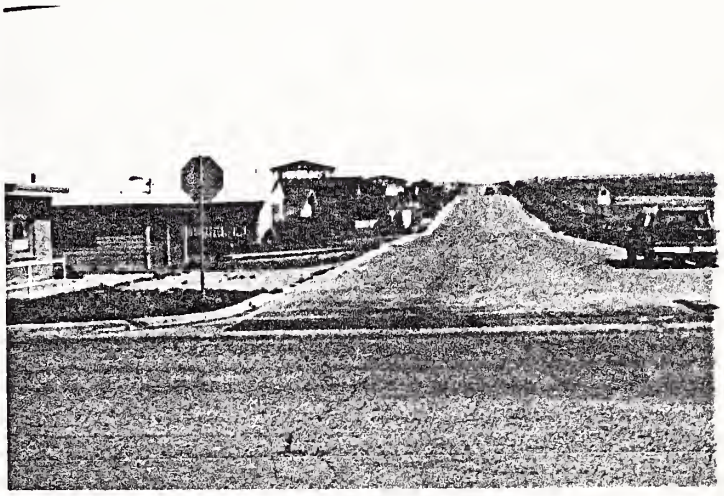
Photograph 1: The large tree located on the northeast corner of the intersection blocks the driver's view of the traffic approaching from the west on Eleventh Street. The stop sign is located 40 feet from the edge of Eleventh Street.

Photograph 2: The intersection approach from the north on Sixteenth Avenue is 40 feet wide and slopes toward the intersection at a grade of approximately 1%.

Photograph 3: The east approach to the intersection is flat with relatively few visual obstructions adjacent to the roadway.

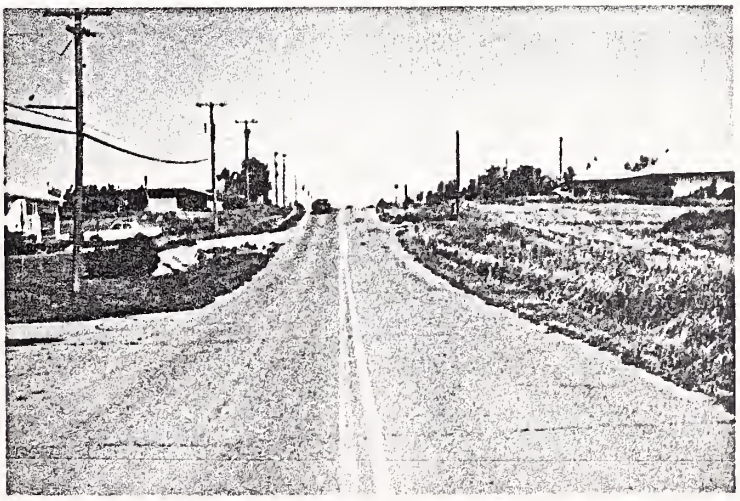
Photograph 4: The intersection cannot be seen from the west approach due to the sharp change in the grade of the roadway. The intersection is 100 feet east of the top of the grade shown in this photo.

Photograph 1



Photograph 2

Photograph 3



Photograph 4

Accident History

One accident occurred at Site 6 during the years of 1985 through 1988. This accident involved an eastbound vehicle on Eleventh Street and a vehicle making a left turn onto Eleventh from Sixteenth Avenue North. The angle collision was caused by the driver on Sixteenth Avenue North failing to yield the right of way. The accident took place at night when conditions were clear and dry. No one was injured as a result of the collision. Additional information concerning this accident is presented below and in the collision diagram in Figure 6A.

Although Montana Highway Patrol records indicate only one accident occurred at this site during the 4-year study period, the County Road Superintendent reports that there have been numerous accidents at this location.

ACCIDENT DATA

SITE 6: 11th St. & 16th Ave. W. **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
	1		

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
			1			

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
					1						

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
																						1	

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
	1		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
1				

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
1			

NO. OF ACCIDENTS BY ACCIDENT TYPE

Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
1									

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
				1				

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)					
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.		1			1

COLLISION DIAGRAM – 11TH & 16TH

6/18/86 2245
C D Nite

ESTIMATED AVERAGE DAILY TRAFFIC

1500 VPD

1600 VPD — 1830 VPD

RESIDENTIAL AREA

PEAK HOUR TURNING MOVEMENTS

22 55

12 — 49

56 — 57

4:45 — 5:45 7/24/89

SYMBOLS: VEHICLE PATH; PEDESTRIAN PATH; BACKING VEHICLE; PARKED VEHICLE; FIXED OBJECT; FATAL ACCIDENT; INJURY ACCIDENT (No. Injured)

COLLISION TYPES: REAR END; HEAD ON; SIDE SWIPE; OUT OF CONTROL; LEFT TURN; ANGLE; NON-COLLISION

WEATHER: C = Clear; CLDY = Cloudy; F = Fog; S = Snow; SL = Sleet

PAVEMENT: D = Dry; W = Wet; S = Snow; I = Icy

DATE: Mo - Day - Yr

TIME: 0 - 2400 Hrs

EXAMPLE: DATE 2/22/84 1600 TIME; WEATHER C D DAY LIGHT; PAVEMENT

18"x 36" Stopwhen Occupied

36"x 36"

30"x 30" STOP

30"x 30" STOP

30"x 30" STOP

16TH AVENUE W

10TH ST. W

16TH AVE W

16TH AVE. W

40'

RICH ST. W

Havre Middle School

1%

36"x 36" Stop When Occupied 18"x 36"

40'

36"x 36" Stop When Occupied 18"x 36"

8' Chain Link Fence

22'

22'

SPEED LIMIT 35 24"x 30"

1%

6%

FLAT

0.8%

36"x 36"

Wheat Field

SPEED LIMIT 25 24"x 30"

SPEED CHECKED BY RADAR 24"x 18"

18"x 36" Stop When Occupied 36"x 36"

BETTER FOR BUSINESS 24"Dia.

11TH STREET

Private Dirt Road

Wheat Field

36"x 36"

N

Approx. Scale 1" = 100'

Site 6
Existing Conditions & Collision Diagram
Figure 6A

Recommended Improvements

There is a major sight-distance problem at this site. A vehicle at the stop sign on Sixteenth Avenue cannot see the traffic approaching the intersection from the west. This is caused by several problems. The stop sign is located 40' from the north edge of Eleventh Street. Sight-distance obstructions located on the northwest corner of the intersection include trees, a steel rail fence, tall grass and shrubs, and parked vehicles. There is also a significant grade change 100' west of the intersection. The road changes from flat to a 6% grade sloping to the west.

Several minor changes to the signing at this site will improve the effectiveness of the signs. For instance, the 35 mph speed limit sign located on the north side of Eleventh, west of the intersection, is mounted only 3' above the ground (5' is the minimum mounting height). The school crossing sign on the south side of Eleventh is located 175' from the crosswalk which reduces its effectiveness. These and other modifications to the site signing are mentioned as recommended improvements.

The following recommendations address problems and deficiencies at the site:

List of Improvements	Estimated Cost
• Relocate the stop sign of Sixteenth Avenue to a point 15' north of Eleventh Street. This will require a similar relocation of the pedestrian crosswalk. It will be necessary to install pin-down curbing to create an island on the northwest corner of the intersection for the stop sign.	$ 750.00
• Restrict parking on the northwest corner of the intersection.	100.00
• Relocate the "25 mph" speed limit sign on the south side of Eleventh Street to a point approximately 600' west of the intersection.	100.00
• Relocate the "35 mph" speed-limit sign on the north side of Eleventh to a point approximately 600' west of the intersection.	200.00
• Remove the four "School Crossing" signs on Eleventh Street.	100.00
• Install an advance "School Crossing" sign (S1-1, 36"x36") on the east side of Sixteenth Avenue just north of the intersection with Eleventh Street.	180.00
• Install a "School Crossing" sign (S2-1, 36"x36") at the crosswalk at the intersection of Sixteenth Avenue and Tenth Street West and install a similar sign at the intersection of Sixteenth Avenue and Rich Street.	360.00
• Install a "Side Road" warning sign (W2-2, 30"x30") and a "20 mph" advisory speed plate (W13-1, 18"x18") on the south side of Eleventh approximately 150' west of the intersection.	180.00

List of Improvements	Estimated Cost
• Keep the grass and weeds cropped close to the ground along the north edge of Eleventh Street, west of the intersection. This will increase available sight distance at the intersection. (No Cost Provided)	
Total Improvement Costs:	**$1,970.00**
Benefit/Cost Radio:	**0.35**
• **Long-Term Improvement**: The sight-distance problems at this intersection are caused by the roadway grades on Eleventh Street west of the junction. This portion of Eleventh Street should be reconstructed with a longer vertical curve and flatter grades. The crest of the hill should be cut down by 3' or 4'.	$50,000.00

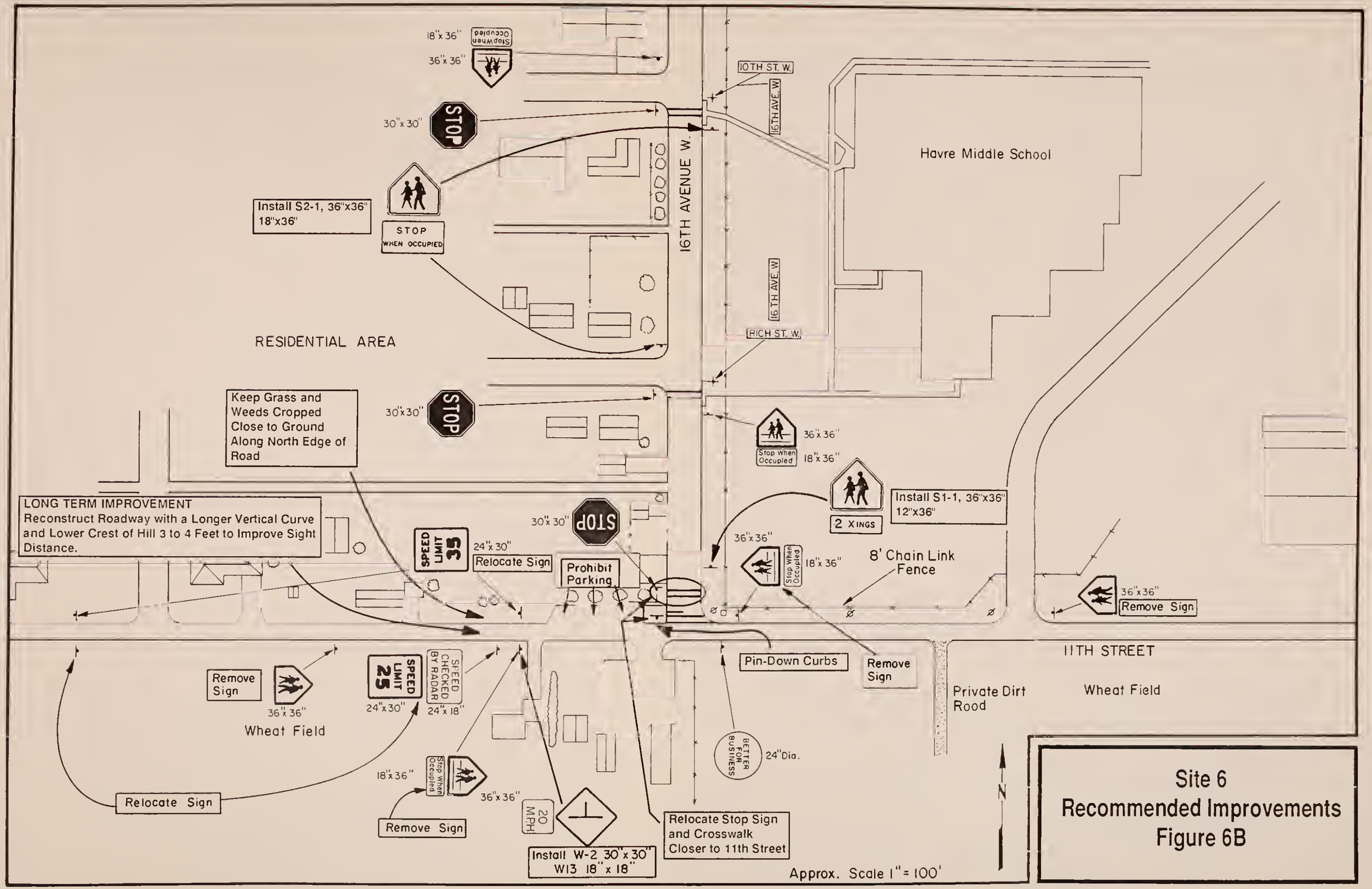
Hazard Index Calculation Form

Site 6: 11th St. & 16th Ave. W.

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	0.25	acc/yr	10	x	0.164	=	1.64
Accident Rate	0.29	acc/MVE	7	x	0.225	=	1.58
Accident Severity	4,300	dollars	45	x	0.191	=	8.60
Volume/Capacity Ratio	0.31		47	x	0.082	=	3.85
Sight Distance Ratio	0.89	(wt. avg.)	42	x	0.074	=	3.11
Driver Expectancy	1.67	(wt. avg.)	28	x	0.149	=	3.92
Information System Deficiencies	1.67	(wt. avg.)	28	x	0.115	=	3.22

Hazard Index: 25.92
Cost of Recommended Improvements: $1,970.00
Cost Factor: 100

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(25.92 x .75) + (100 x .25) = 44.44



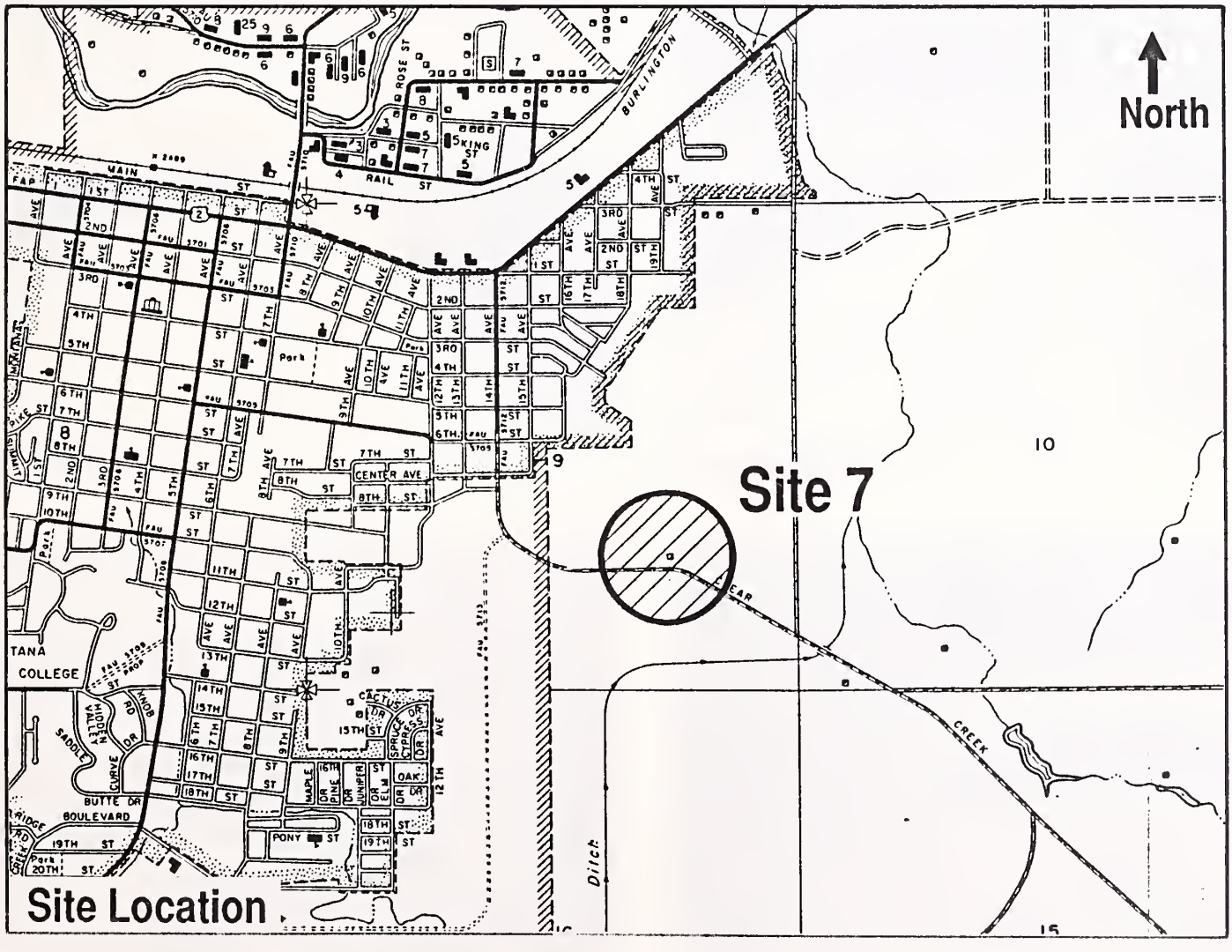
Site 6
Recommended Improvements
Figure 6B

Site 7

Site 7
Existing Conditions

This site consists of a curve on the Clear Creek Road approximately one-quarter mile east of the city limits as shown below. The Clear Creek Road, a farm-to-market route, serves farms and ranches southeast of Havre and is also used as a commuter route by people living in several small residential developments. The roadway through this site is paved, approximately 27 feet wide, and marked with a double solid yellow centerline, which is in good condition. The road has no edgeline striping. A reverse curve warning sign located east of the curve is the only warning sign at this site.

The curve in the Clear Creek Road is the result of a 30° change in roadway alignment and has a superelevation of 6.5%. The overall grade slopes toward the west at approximately 2%. The geometric layout of the site is shown in Figure 7A. Traffic counts taken by the Department of Highways in 1988 indicate this portion of Clear Creek Road has an average daily traffic volume of 490 vehicles.



Site Photographs

Photograph 1: This reverse curve sign is located on the east approach to the site. The roadway is marked with a yellow double solid centerline throughout the site.

Photograph 2: There is no warning sign on the west approach to the curve. The gas line building can be seen on the left in this photo.

Photograph 3: A gravel driveway is located on the outside of the curve. This photo shows the west approach to the curve. Southeast Havre can be seen in the distance..

Photograph 4: This picture of the east approach was taken while standing in the gravel driveway to the gas line building. The east approach is straight and slopes toward the intersection at a grade of 1.5%.

Photograph 1

Photograph 2

Photograph 3

Photograph 4

Accident History

The curve on Clear Creek Road was the site of two single-vehicle accidents during the four-year study period. In both cases, the vehicle left the roadway in the curve while traveling at a high rate of speed. Both accidents occurred at night when it was clear and dry. One accident involved an eastbound vehicle that slid off the north side of the roadway and rolled over, hitting a gas pipeline sign in the process. No one was incurred as a result of the incident. The other accident occurred when a westbound motorist lost control of his vehicle in the curve and left the roadway. The vehicle crossed the ditch on the south side of the road and entered the adjacent field. The vehicle rolled over twice throwing the driver and passenger into the field. The driver was killed and the passenger severly injured. Alcohol was involved in this accident. Refer to the data below and the collision diagram on Figure 7A for additional details of the accident history at this site.

According to the County Road Superintendent, a fatality accident occurred at this site during the summer of 1989. An eastbound vehicle missed the curve and rolled over after leaving the roadway.

ACCIDENT DATA

SITE 7: Clear Creek Road **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
1		1	

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
1						1

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1										1

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
				1																			1

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
	2		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
2				

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
2			

NO. OF ACCIDENTS BY ACCIDENT TYPE

Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
		1				1			

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
	1		1					

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)					
Fatality Acc. (No. of Deaths)			1 (1)		1 (1)
Property Damage Only Acc.	1				1

ESTIMATED AVERAGE DAILY TRAFFIC
490 VPD

SYMBOLS
- VEHICLE PATH
- PEDESTRIAN PATH
- BACKING VEHICLE
- PARKED VEHICLE
- FIXED OBJECT
- FATAL ACCIDENT
- INJURY ACCIDENT (No Injured)

COLLISION TYPES
- REAR END
- HEAD ON
- SIDE SWIPE
- OUT OF CONTROL
- LEFT TURN
- ANGLE
- NON-COLLISION

WEATHER
C = Clear
CLDY = Cloudy
F = Fog
S = Snow
SL = Sleet

PAVEMENT
D = Dry
W = Wet
S = Snow
I = Ice

DATE
Mo - Day - Yr

TIME
0 - 2400 Hrs

EXAMPLE
DATE 2/22/84 1500 TIME
WEATHER C.D DAY LIGHT
PAVEMENT

30"x 30"

CITY LIMITS 30"x24"

SPEED LIMIT 25 24"x30"

SPEED LIMIT 35 24"x36"

Agricultural Land

Gas Line Valve Station

27'

Clear Creek Road

2%

6.5%

6" Steel Post Marking Gas Line

Agricultural Land

Buried Gas Line

6" Steel Post Marking Gas Line

1.5%

27'

30"x 30"

Agricultural Land

12/15/85 0526
Cldy./D. Nite

2/21/87 0015
C. D. Nite
1 FAT.
1 INJ

COLLISION DIAGRAM—
CLEAR CREEK RD. CURVES

N

Approx. Scale 1"= 200'

Site 7
Existing Conditions & Collision Diagram
Figure 7A

Recommended Improvements

The only warning sign at this site is a reverse curve warning sign on the east approach. This sign is typically used on a set of curves that are less than 600' apart. The two curves on the Clear Creek Road are approximately 700' apart. Although there are no major sight-distance limitations, the alignment of the roadway can be difficult to identify at night.

A spot speed test was performed on vehicles as they approached this site. The results indicated the average approach speed is 45 mph, and the 85th percentile speed is 55 mph. A ball bank indicator was used to determine that the maximum safe speed for the curve at this site is 35 mph.

The following recommendations address the safety deficiencies at this site:

List of Improvements	Estimated Cost
• Remove the existing reverse curve warning sign located east of the site.	$ 50.00
• Install curve warning signs (W1-2, 30"x30") along with 35 mph advisory speed plates (W1-13, 18"x18") on both approaches to this curve. Place these signs 400' from the beginning of the curve as shown in Figure 7B.	360.00
• Install 13 white, bi-directional reflectorized delineators along the outside of the curve. Figure 7B shows the recommended placement and spacing of the delineators.	260.00
• The curve west of the site should be identified with a curve warning sign (W1-2, 30"x30"). This warning sign should be placed 400' from the beginning of the curve. Eastbound traffic from town must climb a grade into the curve and have slower approach speeds. The warning sign for the eastbound traffic should be placed 100' from the beginning of the curve.	280.00
Total Improvement Costs:	**$ 950.00**
Benefit/Cost Ratio:	**13.61**
• **Long-Term Improvement**: It is desirable to eliminate this problem curve by reconstructing the roadway with a flatter curve alignment as shown in Figure 7B.	$65,000.00

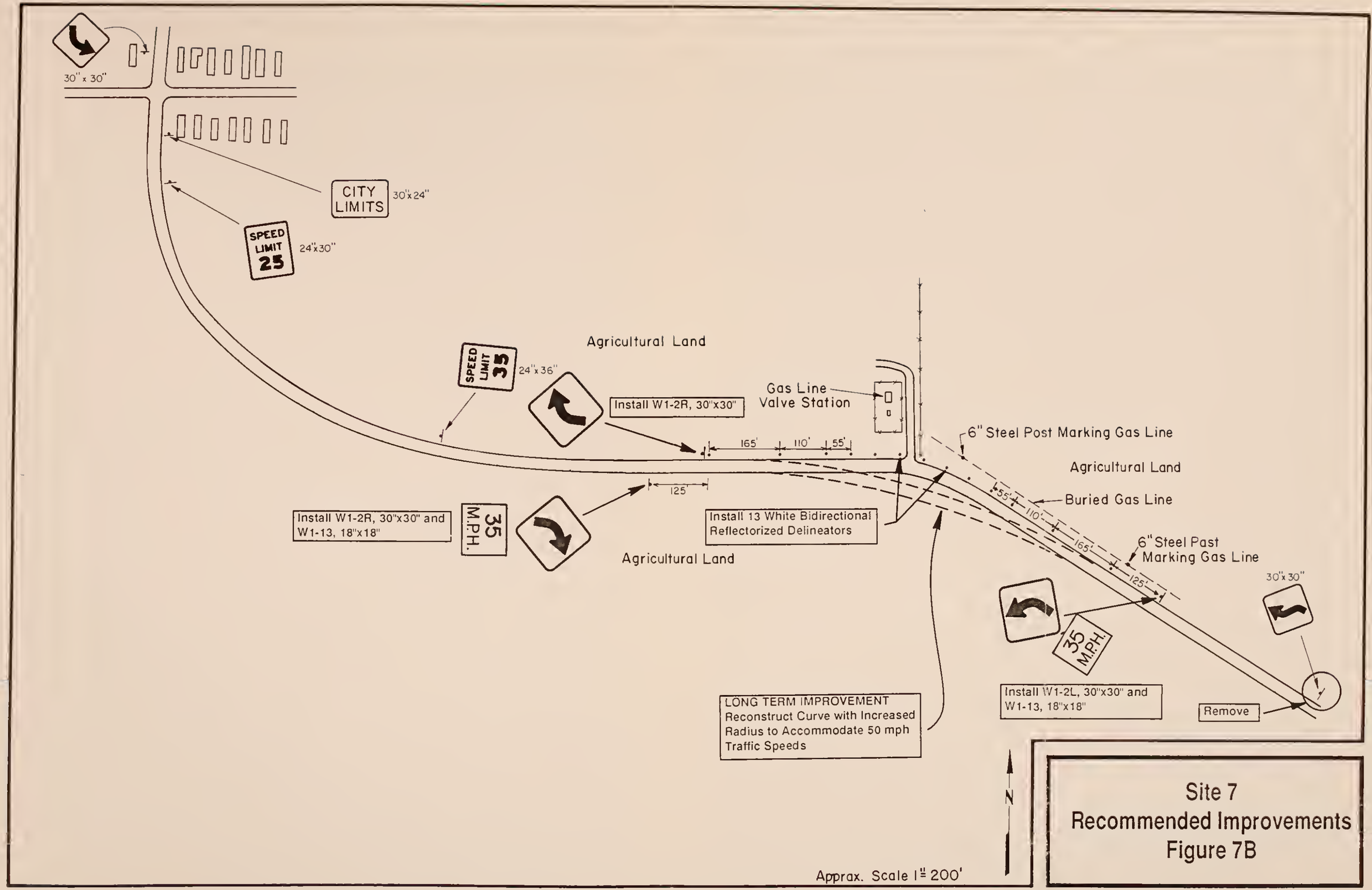
Hazard Index Calculation Form

Site 7: Clear Creek Road

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	0.50	acc/yr	17	x	0.164	=	2.79
Accident Rate	2.91	acc/MVE	45	x	0.225	=	10.13
Accident Severity	12,400	dollars	69	x	0.191	=	13.18
Volume/Capacity Ratio	0.08		24	x	0.082	=	1.97
Sight Distance Ratio	1.63	(wt. avg.)	6	x	0.074	=	0.44
Driver Expectancy	2.00	(wt. avg.)	33	x	0.149	=	4.62
Information System Deficiencies	3.33	(wt. avg.)	56	x	0.115	=	6.44

Hazard Index: 39.57
Cost of Recommended Improvements: $950.00
Cost Factor: 98

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(39.57 x .75) + (98 x .25) = 54.18

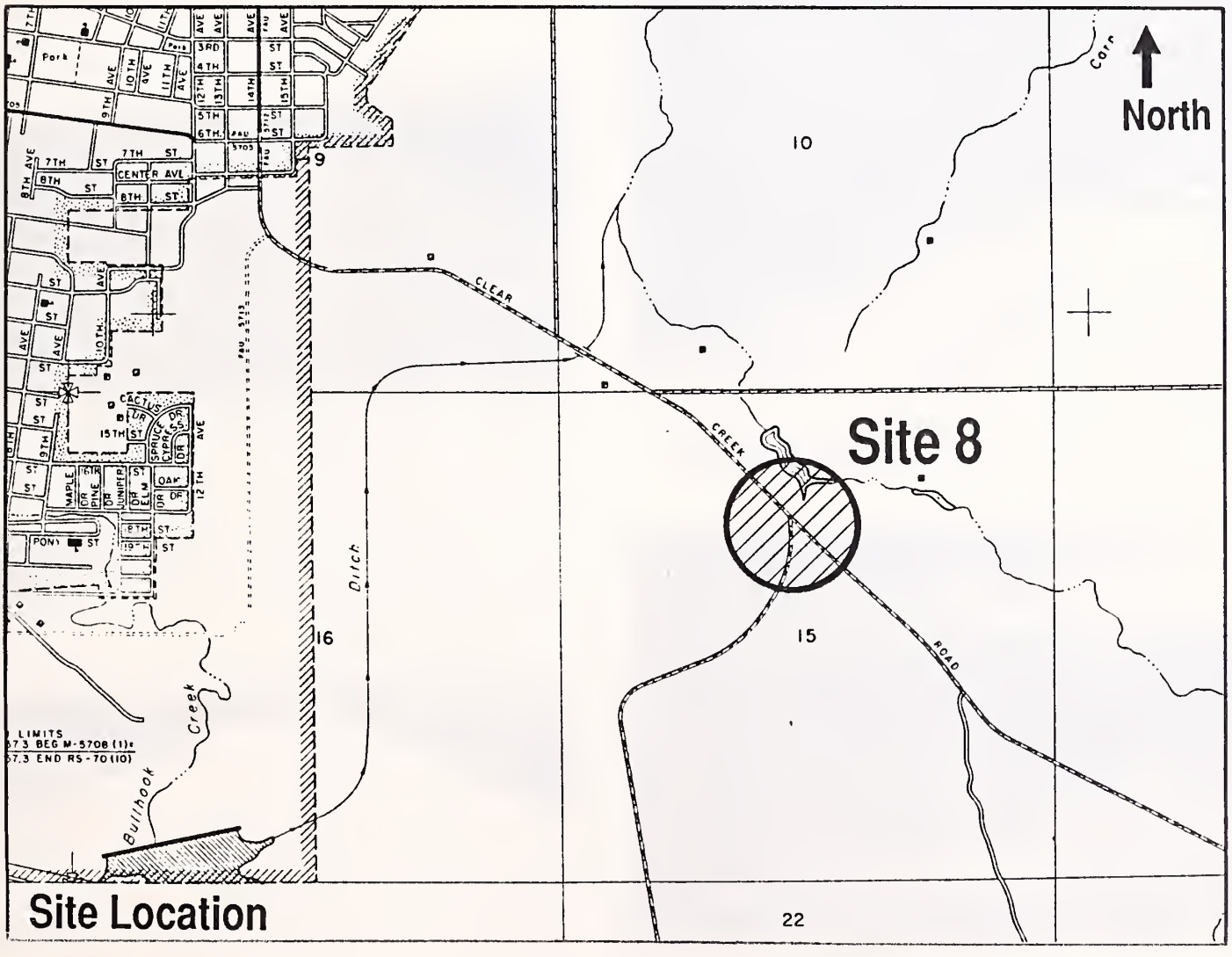


Site 7
Recommended Improvements
Figure 7B

Site 8

Site 8
Existing Conditions

The intersection of the Clear Creek Road and Bull Hook Road, 1.5 miles southeast of Havre, is the location of Site 8 (see map below). Both roads at this site are gravel and approximately 30 feet wide. Clear Creek Road is straight throughout the site while gently sloping to the west at less than 1.5%. Bull Hook Road joins Clear Creek Road at a 45^{o} angle creating a "Y" intersection. Bull Hook Road slopes toward the intersection with grades decreasing from 5 to 2.5%. The only form of traffic control at the site is a yield sign for the approaching traffic on the Bull Hook Road. The predominant traffic flow is between the west approach on Clear Creek Road and the south approach on Bull Hook. Traffic volumes were estimated to be 380 and 330 VPD, respectively. The traffic on Clear Creek Road east of the intersection was estimated to be only 70 VPD. Land surrounding the site is used for wheat production and pasture. A 30 to 40-foot-deep coulee is located immediately east and north of the intersection with the storm runoff passing under the Clear Creek Road through a 6-foot culvert. This coulee continues to deepen on the north side of the intersection. Additional site details are shown in Figure 8A.



Site Photographs

Photograph 1: The west approach to the intersection on the Clear Creek Road is 28 feet wide and gravel surfaced. The road surface was in good condition at the time of the site evaluation.

Photograph 2: The Bull Hook Road makes a wide curve as it approachs the junction from the south. The land adjacent to this site is used for wheat production and pasture.

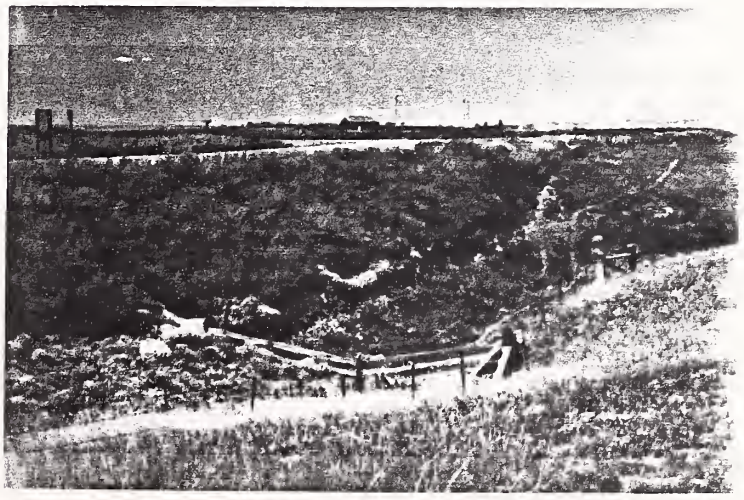
Photograph 3: The intersection is difficult to see on the approach from the east. Clear Creek Road east of the intersection carries approximately 70 vehicles per day.

Photograph 4: This picture was taken from the field north of the intersection. It shows the large coulee that is immediately north of this site.

Photograph 1

Photograph 2

Photograph 3



Photograph 4

Accident History

Two single-vehicle accidents occurred at this intersection during the study period. In both cases the vehicle was approaching the intersection from the south on the Bull Hook Road. The vehicle went off the right side of the road striking a fence and the yield sign at the intersection in one accident. Alcohol was a contributing factor. The other accident occurred when the driver lost control of the vehicle due to excessive speed and failed to make the left turn onto the Clear Creek Road. The vehicle rolled over as it entered the borrow ditch on the north side of the intersection. Both accidents took place during low-light conditions when the weather was clear and dry. No one was injured in either accident. A diagram of these accidents is presented in Figure 8A and additional accident data is set forth below.

ACCIDENT DATA

SITE 8: Clear Creek Road & Bull Hook Road **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
	2		

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
			1			1

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
			1				1				

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
																		1				1	

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
	1		1

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
2				

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
2			

NO. OF ACCIDENTS BY ACCIDENT TYPE

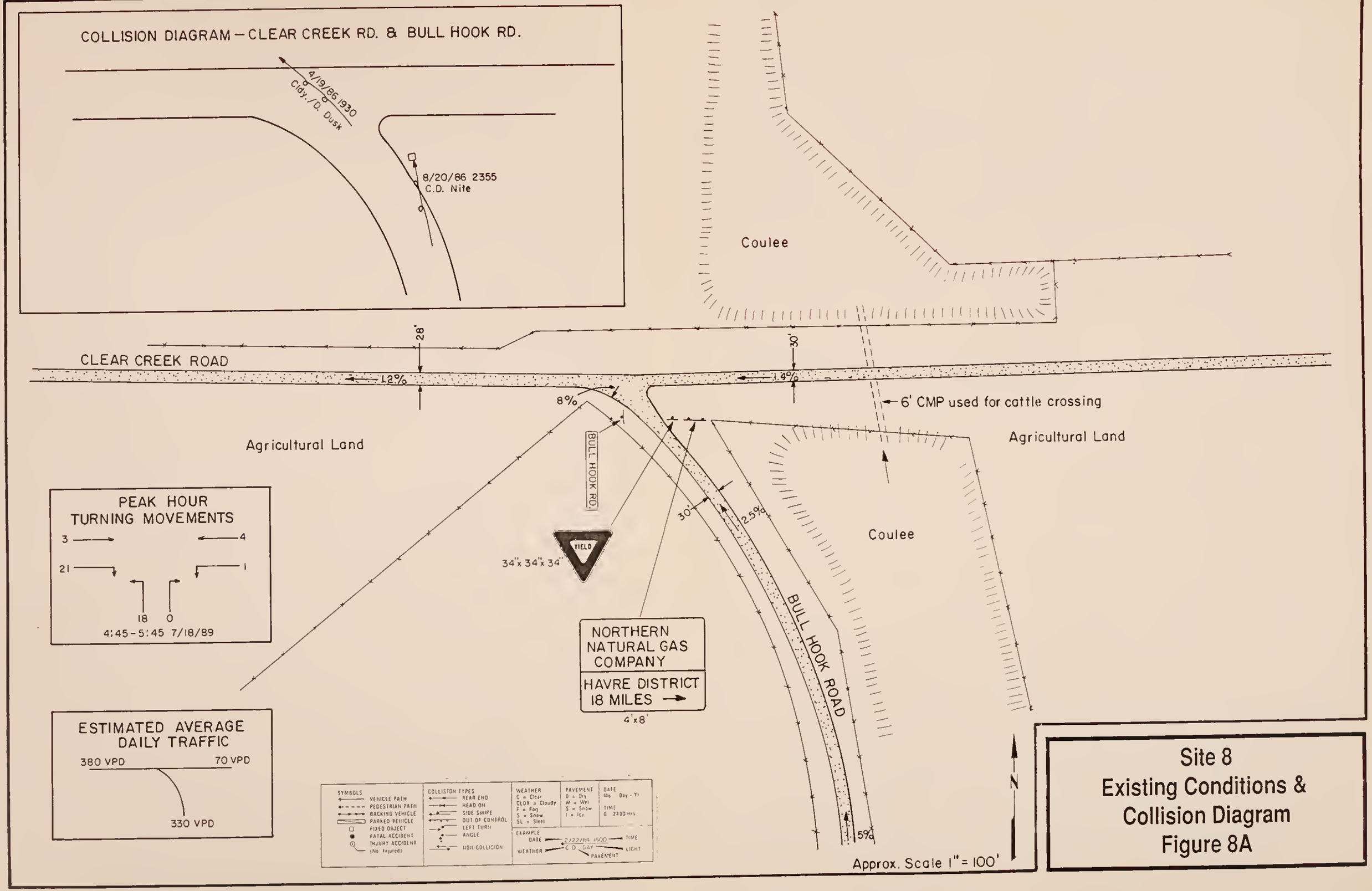
Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
		1				1			

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
	1		1					

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)					
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.		2			2



Site 8
Existing Conditions & Collision Diagram
Figure 8A

Recommended Improvements

Historically, Clear Creek Road has been the major roadway through this part of Hill County, with Bull Hook Road being a minor road.

Traffic control at this intersection is provided by a "Yield" sign on Bull Hook Road. This yield condition has been relatively effective in the past and was not a contributing factor in either of the two accidents that occurred at this intersection during the 4-year study period.

A spot speed study conducted at this site indicated that the average approach speed is 42 mph from from the west and 38 mph from the south. A ballbank indicator was used to determine that the maximum safe speed for the curve between the south and west legs of the intersection is 30 mph.

The County is planning to pave Clear Creek Road west of the intersection and the Bull Hook Road. This paving project will most likely result in increased approach speeds.

Although Clear Creek Road is relatively flat and free of sight-distance obstructions, the location of the intersection is difficult to identify on both the east and west approaches, especially at night. The recommended short-term improvements for this site are to install advance warning signs on all three approaches to the intersection.

The traffic volumes and turning movement count data indicate that the major flow of traffic is between the west and south legs of the intersection. This is the result of a growing residential development on Bull Hook Road.

It is desirable from a traffic-operation standpoint to change the traffic control plan of this intersection giving the right-of-way to the south and west approaches and controlling the low-volume east approach with a "Yield" sign. Altering the control of the intersection without reconstructing the alignment of the approaches may create a conflict between eastbound vehicles and approaching traffic from the south.

The recommended long-term improvement is to reconstruct the intersection to increase the radius of the curve between the west and south legs and realign the east approach to form a "T" intersection. The intersection signing should then be altered and the east approach controlled with a "Yield" sign.

The recommendations presented below address the problems at Site 8:

List of Improvements	Estimated Cost
• Install a "Side Road" warning sign (W2-3, 30"x30") on the east approach approximately 300' from the intersection.	$ 140.00
• Install a "Side Road" warning sign (W2-3), 30"x30") and a 30 mph advisory speed plate (W13-1, 18"x18") on the west approach approximately 300' from the intersection.	180.00

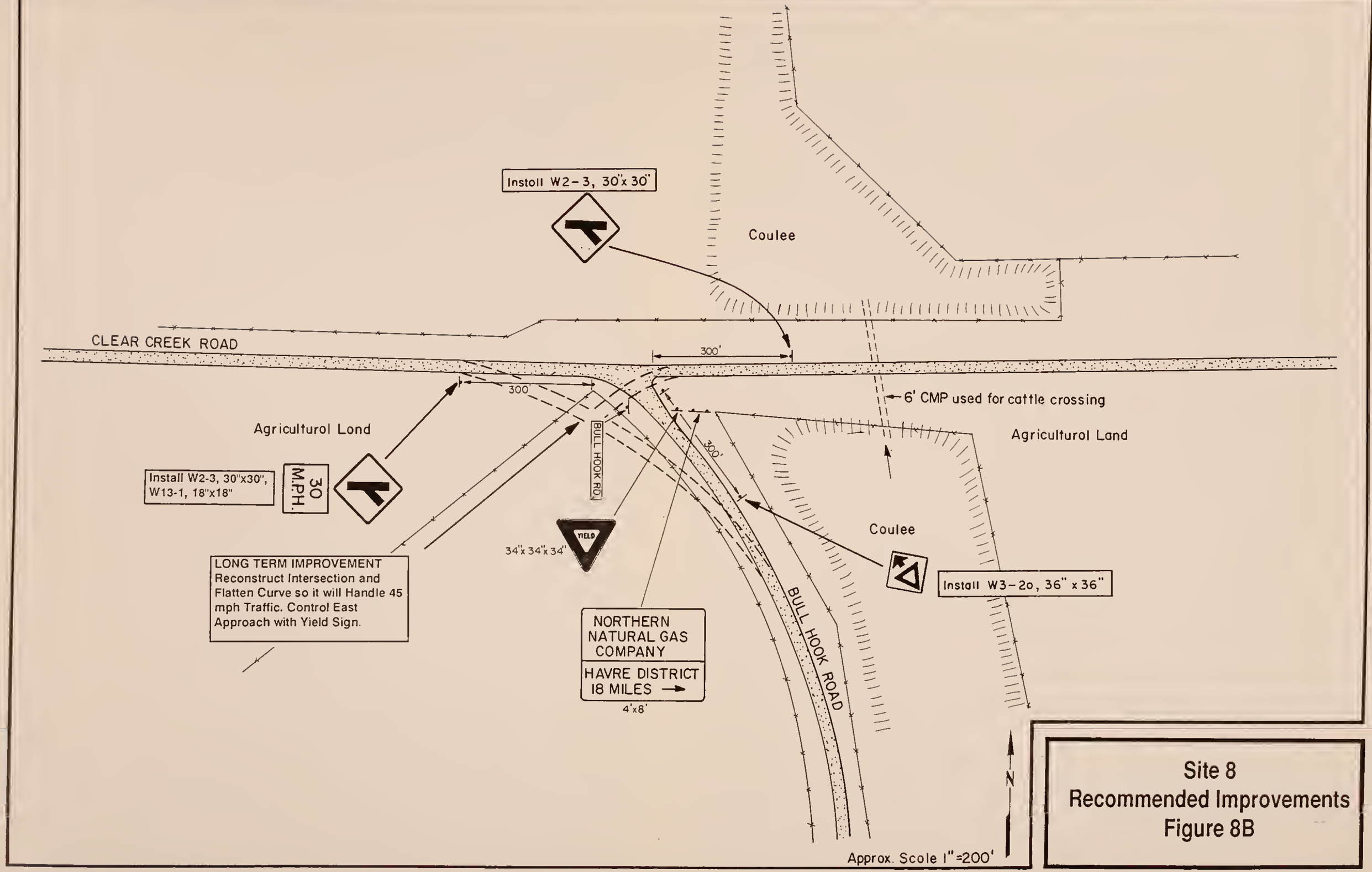
List of Improvements	Estimated Cost
• Install a "Yield Ahead" warning sign (W3-2a, 36"x36") on the south approach approximately 300' from the existing yield sign.	140.00
Total Improvement Costs:	**$ 460.00**
Benefit/Cost Ratio:	**1.50**
• **Long-Term Improvement**: Reconstruct the intersection by increasing the radius of the curve between the west and south legs and realigning the east approach to intersect the curve at a right angle. Remove all existing signing and install a "Yield" sign and a "Yield Ahead" warning sign on the east approach. Install curve warning signs on the west and south approaches.	$25,000.00

Hazard Index Calculation Form

Site 8: Clear Creek Road & Bull Hook Road

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	0.50	acc/yr	17	x	0.164	=	2.79
Accident Rate	3.66	acc/MVE	56	x	0.225	=	12.60
Accident Severity	12,300	dollars	69	x	0.191	=	13.18
Volume/Capacity Ratio	0.08		24	x	0.082	=	1.97
Sight Distance Ratio	2.00	(wt. avg.)	0	x	0.074	=	0.00
Driver Expectancy	2.33	(wt. avg.)	39	x	0.149	=	5.46
Information System Deficiencies	4.00	(wt. avg.)	67	x	0.115	=	7.71
		Hazard Index:					43.71
		Cost of Recommended Improvements:					$460.00
		Cost Factor:					99

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(43.71 x .75) + (99 x .25) = 57.53



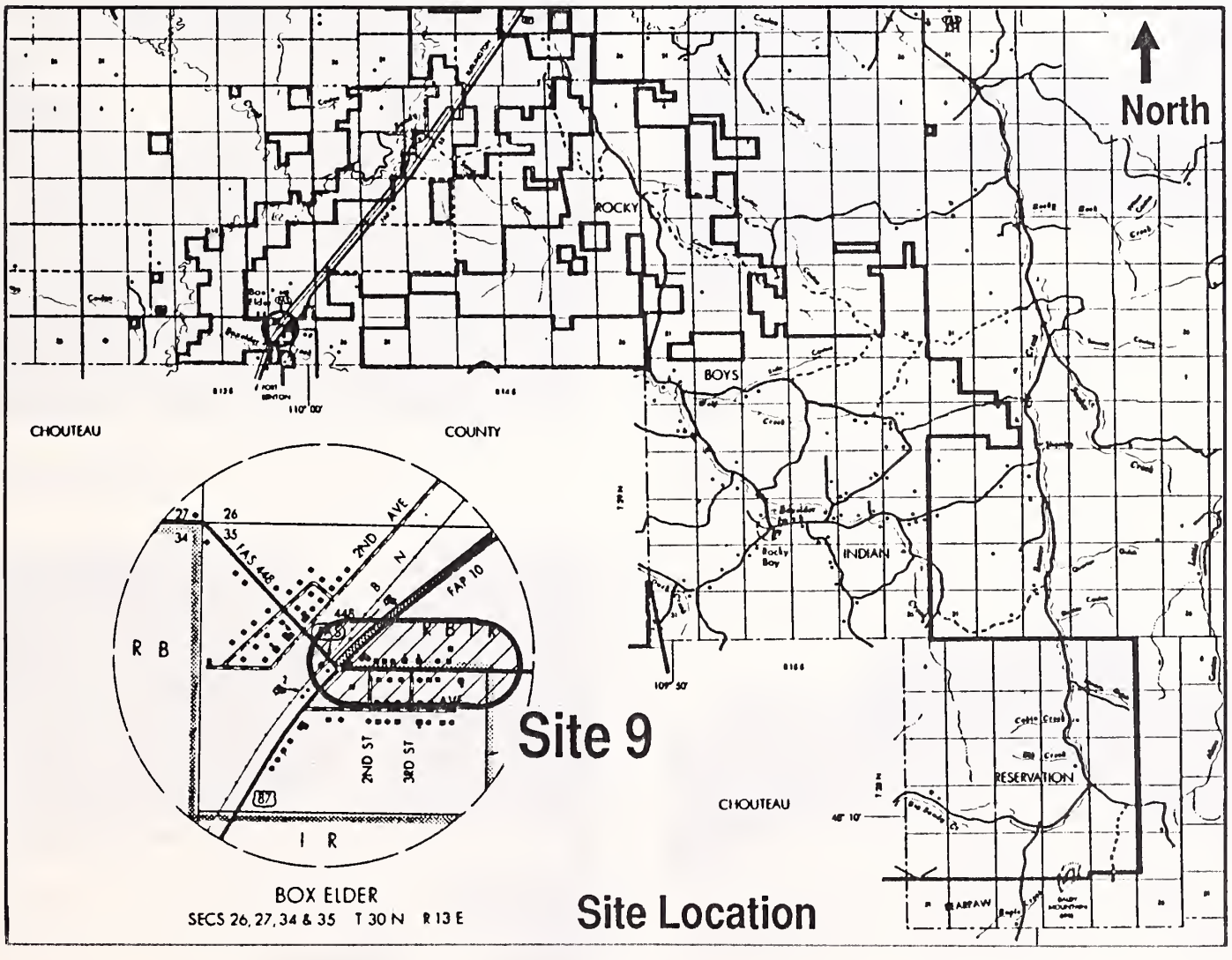
Site 8
Recommended Improvements
Figure 8B

Site 9

Site 9
Existing Conditions

This site is located east of U.S. Highway 87 on Main Street in the community of Box Elder (see map below). The study area is approximately four blocks long extending east from the intersection at U.S. Highway 87 to the edge of town, just past the Box Elder School. Main Street is relatively flat and has a 28-foot-wide paved surface. It lies within a wide, uncluttered right-of-way that is approximately 70 feet wide. The street is equipped with lights which are located along the south side of the corridor. Main Street is lined with residential homes, two churches, and, at the east end, the Box Elder School. This street has a posted speed limit of 15 mph.

Main Street has a straight east-west alignment with a single bend at the west end of the site where the road curves to the northwest to intersect U.S. Highway 87. Two local residential streets intersect Main Street from the south within the study area to form two 90° "T" intersections. Traffic volumes on Main Street were estimated to be approximately 1,090 VPD. Figure 9A contains additional details on the layout of this site.



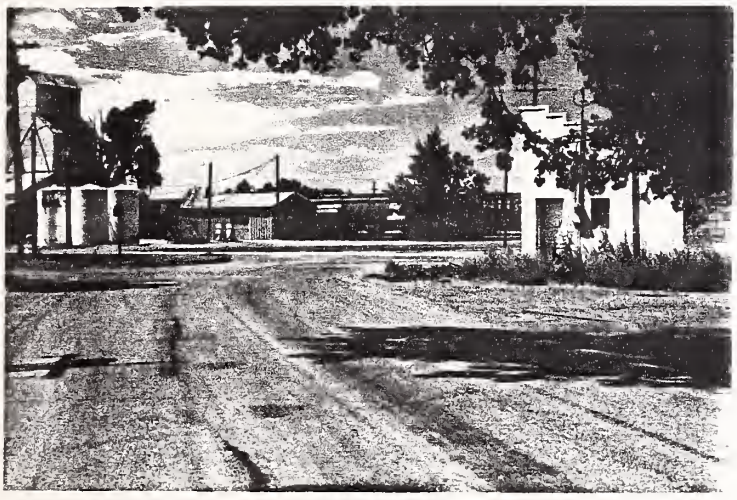
Site Photographs

Photograph 1: The west end of Main Street curves to the right on the approach to the junction with U.S. Highway 87. The driver's view of the stop sign is blocked by the white building on the right.

Photograph 2: Main Street is relatively wide, straight, and lined with numerous large trees. Telephone poles that hold the street lights line the south side of the street.

Photograph 3: This photo shows a view of Main Street looking east from the junction with Third Street. A property owner on the north side of the street has placed large rocks within the right-of-way to protect his fence from errant vehicles.

Photograph 4: This view of Main Street, looking west, shows the Box Elder School on the left. A speed limit sign indicating 15 mph is located across from the school.



Photograph 1

Photograph 2

Photograph 3

Photograph 4

Accident History

Main Street in Box Elder was the site of six accidents during the four-year study period. Four of the accidents were multi-vehicle collisions while two involved single vehicles. The accidents occurred at various locations along Main Street as shown in the collision diagram presented in Figure 9A. One collision, a rear-end accident which injured two people, took place on the westbound approach to the intersection of U.S. Highway 87. Two of the accidents were sideswipes, one of which injured three persons. Another collision resulted when a car backed out of the school parking area and struck an eastbound vehicle. The other two cases were run-off-the-road accidents. Alcohol was involved in all four accidents that occurred at night. Wet pavement and icy-road conditions were contributing factors in four cases. Additional information about the accidents at this site is set forth below.

ACCIDENT DATA

SITE 9: Main Street, Box Elder **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
3	3		

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
1	1				2	2

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1		1	1			1	1		1	

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2	1		1					1							1								

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
2	4		

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
2	2		2	

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
3	2		1

NO. OF ACCIDENTS BY ACCIDENT TYPE

Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
	1	2			2			1	

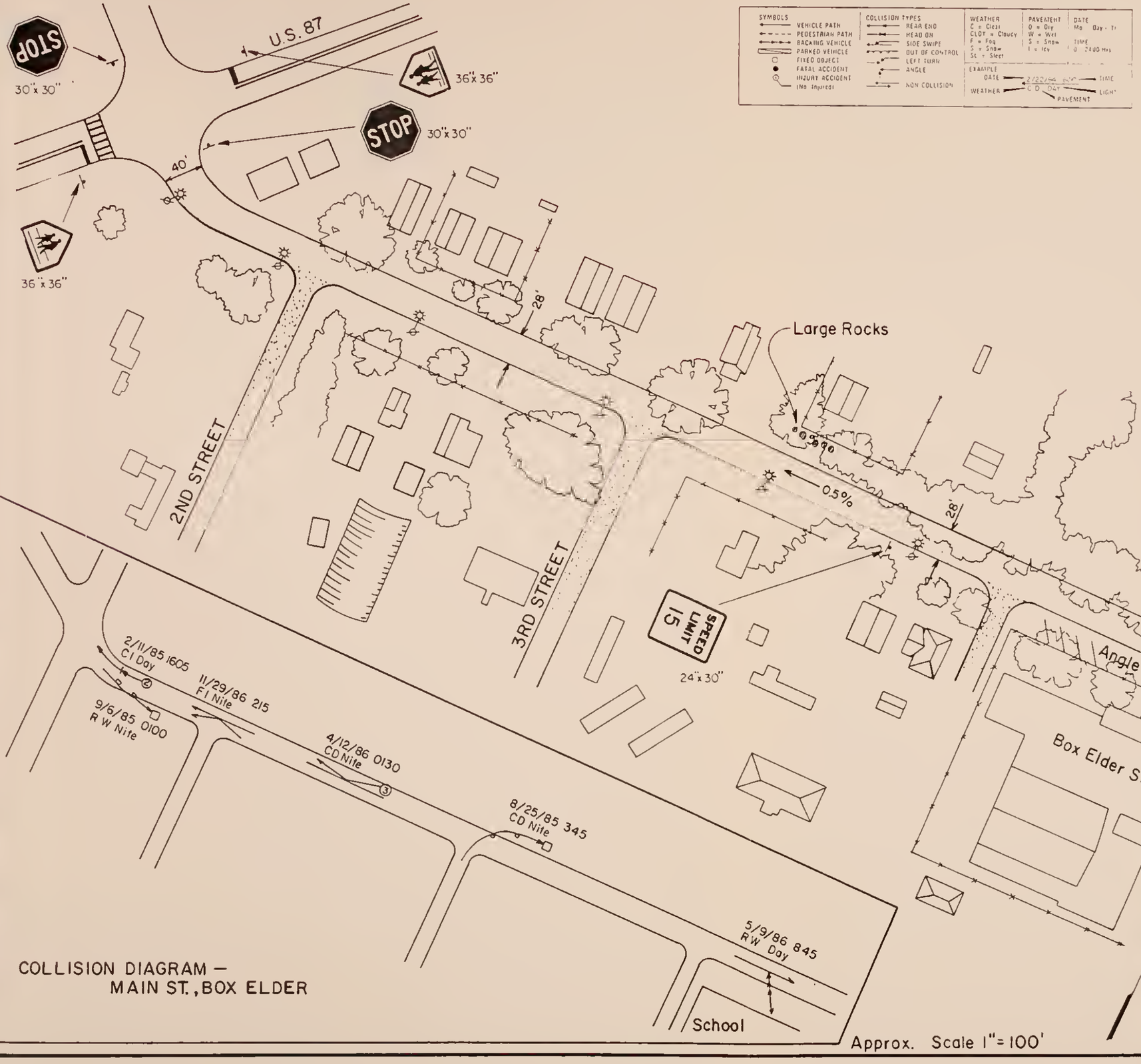
NO. OF ACCIDENTS BY POSSIBLE VIOLATION

No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
1	4				1			

NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)	1 (2)	1 (3)			2 (5)
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.	2	2			4

ESTIMATED AVERAGE DAILY TRAFFIC
1090 VPD



Site 9
Existing Conditions &
Collision Diagram
Figure 9A

Recommended Improvements

A spot speed test was performed at this site to identify the rate of speed vehicles travel along Main Street. The results indicate an average speed of 30 mph and an 85th percentile speed of 32 mph. The 85th percentile speed is typically used to determine the appropriate speed limit for a roadway. The current speed limit of 15 mph does not seem to have any effect on drivers. The speed test was performed in August when the Box Elder School was closed for summer recess.

Two other deficiencies were identified at this site. Since the stop sign at the U.S. Highway 87 intersection is not visible to approaching traffic, a "Stop Ahead" warning sign should be posted. The other deficiency is the lack of pavement markings on Main Street. A centerline that restricts passing maneuvers and edgeline striping will provide the motorist with additional guidance, especially at night.

One safety problem was identified on the north side of Main Street. A resident has placed large rocks in the County right-of-way to protect his fence from vehicle impacts. The rocks constitute a more serious hazard to motorists than the fence and represent a liability to the County since they are on County property. The rocks were involved in at least one fixed-object accident during the study period.

The following recommended improvements address problems and deficiencies at the site:

List of Improvements	Estimated Cost
• Install a "Stop Ahead" sign (W3-1a, 36"x36") 150' from the stop sign on the east approach to the intersection at U.S. Highway 87.	$ 140.00
• Remove the large rocks and brush from the County right-of-way.	500.00
• Install a yellow, double solid centerline and white edgeline stripes along the full length of Main Street.	725.00
• Convert the existing "15 mph" speed limit signs into school speed limit signs by adding a top panel stating "School" (S4-3, 24"x8") and a bottom panel stating "When Children are Present" (S4-2, 24"x10") to each sign. The current sign locations are appropriate.	260.00
• Remove the "Slow Children" sign located at the east end of the site.	50.00
• Install "30 mph" speed limit signs on Main Street. A sign for the eastbound traffic should be placed in the first block east of U.S. Highway 87. The other sign should be installed 400' east of the school for the westbound traffic.	280.00
Total Improvement Costs:	**$1,955.00**
Benefit/Cost Ratio:	**5.51**

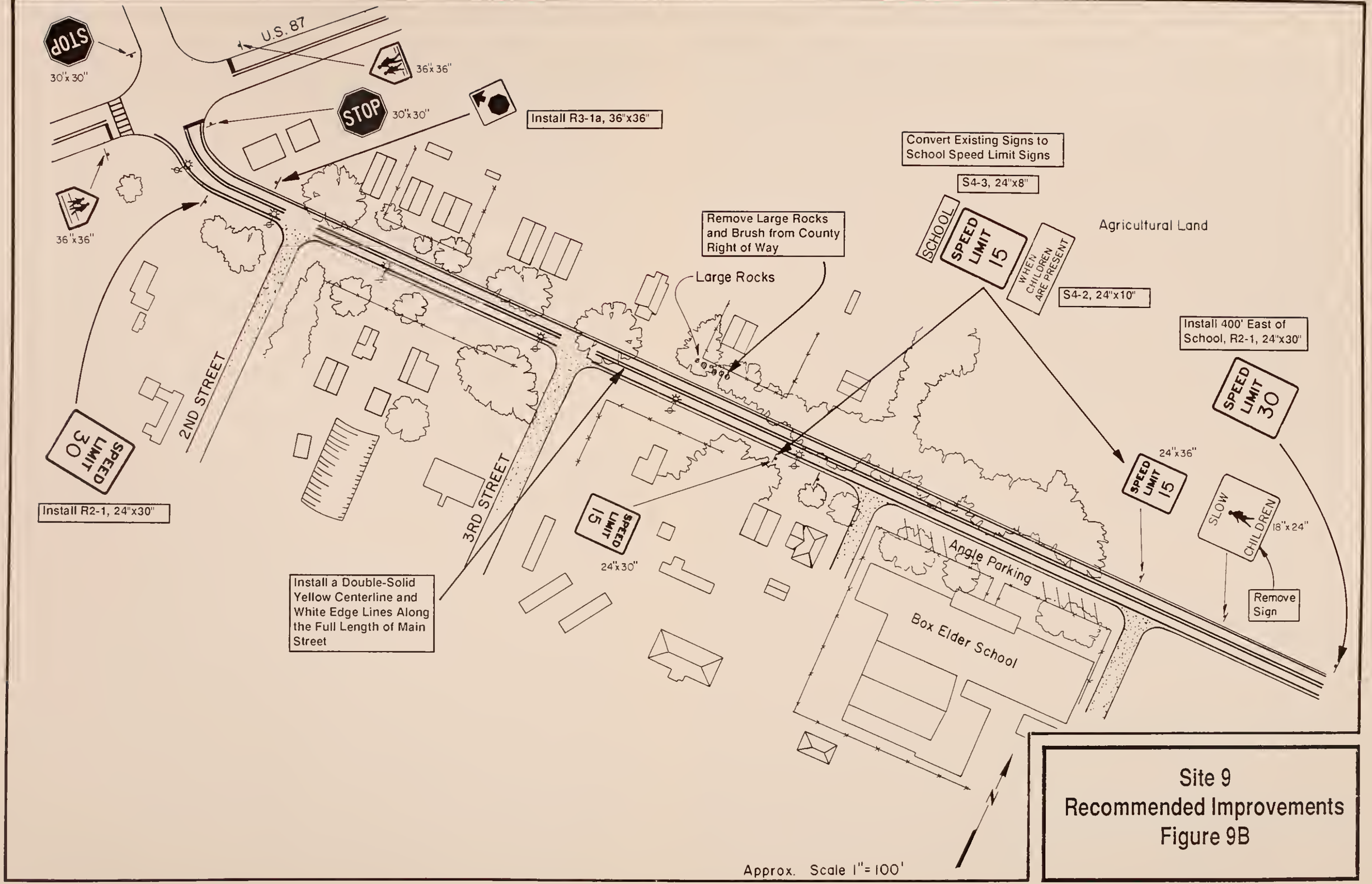
Hazard Index Calculation Form

Site 9: Main Street, Box Elder

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	1.50	acc/yr	33	x	0.164	=	5.41
Accident Rate	3.93	acc/MVE	58	x	0.225	=	13.05
Accident Severity	7,050	dollars	54	x	0.191	=	10.31
Volume/Capacity Ratio	0.17		36	x	0.082	=	2.95
Sight Distance Ratio	0.67	(wt. avg.)	71	x	0.074	=	5.25
Driver Expectancy	1.67	(wt. avg.)	28	x	0.149	=	3.92
Information System Deficiencies	1.67	(wt. avg.)	28	x	0.115	=	3.22

Hazard Index: 44.11
Cost of Recommended Improvements: $1,955.00
Cost Factor: 98

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(44.11 x .75) + (98 x .25) = 57.58

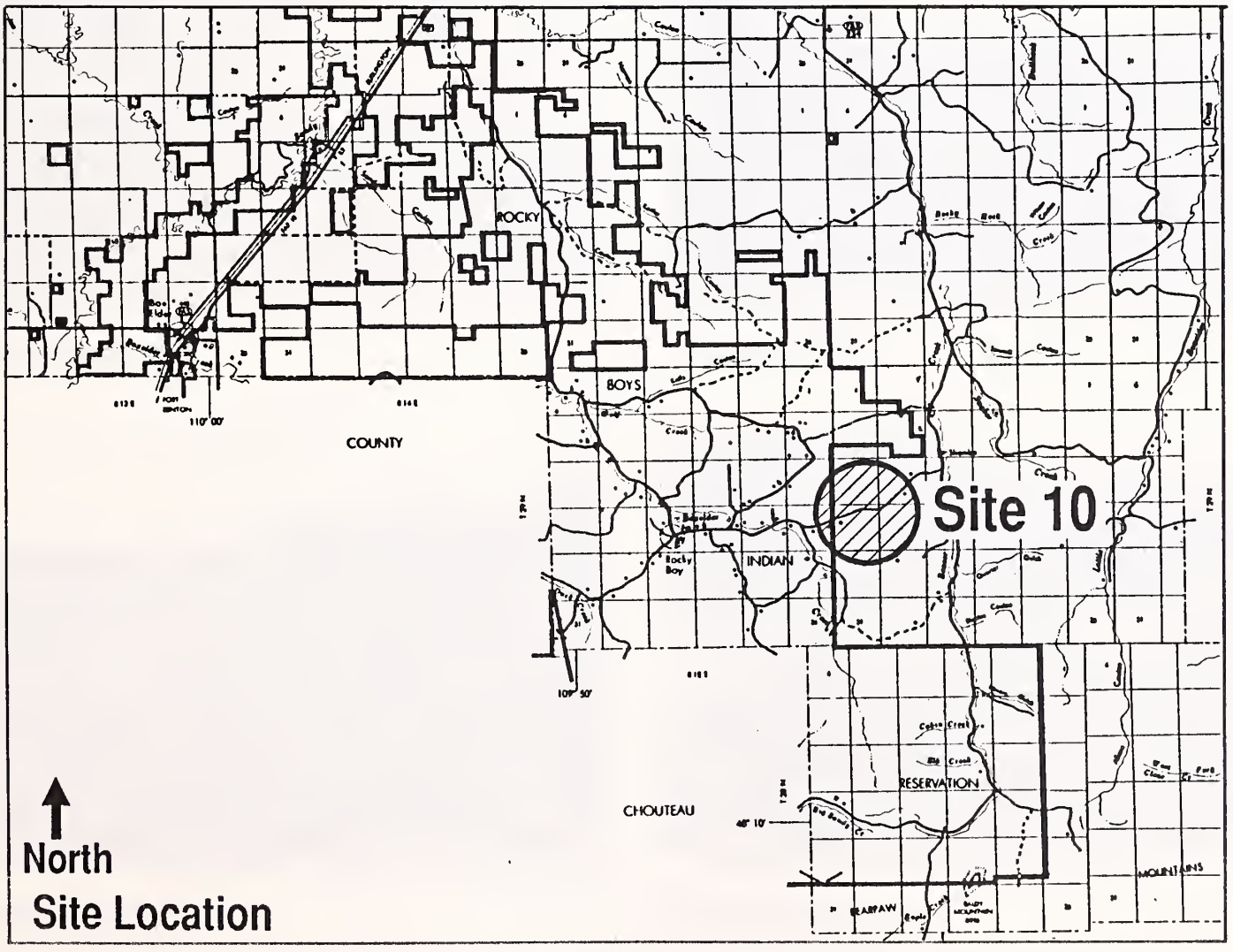


Site 9
Recommended Improvements
Figure 9B

Site 10

Site 10
Existing Conditions

Site 10 is located immediately east of the Rocky Boy Indian Reservation on Taylor Road (see map below). This road is approximately 5.7 miles long and extends from Beaver Creek Road west to the community of Rocky Boy. The county's portion of Taylor Road is 2.5 miles long and goes from Beaver Creek Road to the cattleguard at the reservation boundary. Residents of Rocky Boy use it as a primary route into Havre. It has a 26-foot-wide paved surface from Rocky Boy to the boundary where it changes to a dirt and gravel surface. The study area is 0.9 miles long extending east from the reservation boundary. Taylor Road slopes upward from the reservation boundary at varying rates ranging from 2 to 6%. At the east end of the site the road steepens to a maximum of 12% as it climbs a high ridge. From this point, Taylor Road drops steadily as it approaches Beaver Creek. The roadway includes several curves as shown in Figure 10A. The gravel roadway is approximately 28-feet wide and lies within a 60-foot right-of-way, which is fenced on both sides throughout the site. At the time of the investigation, the road was in good condition with only small segments having a washboard surface. A ranch complex along the south side and a residence on the north side of the road are located within the study area. There is no signing, delineation or other form of traffic control within the site. It was estimated this portion of Taylor Road carries approximately 230 VPD.



Site Photographs

Photograph 1: This photo shows Taylor Road looking west at the reservation boundary. The road changes from pavement (on the reservation) to a dirt/gravel surface at the cattleguard at the west end of the site.

Photograph 2: A ranch complex is located on the south side of Taylor Road midway through the site. This portion of Taylor Road is approximately 28 feet wide.

Photograph 3: There are several broad curves in the road throughout the site. None of the curves are signed or delineated in any way.

Photograph 4: Taylor Road climbs a steep grade at the east end of the site. This photo looking east shows the curves at the beginning of the grade up the hill.

Photograph 1

Photograph 2

Photograph 3

Photograph 4

Accident History

Site 10 was the scene of four accidents between 1985 and 1988. Three were single vehicle run-off-the-road incidents, while the fourth involved a head-on collision. The head-on accident took place in the steep curves at the east end of the site and was caused when one of the vehicles began to skid on the gravel surface. Excessive speed was a factor in this collision. The run-off-the-road accidents took place at various locations along Taylor Road (see the collision diagram on Figure 10A). In one of the single-vehicle accidents, the driver was injured. Alcohol was involved in three of the four incidents. All occurred when it was clear and dry. Two accidents occurred in the daylight; one at dawn, and one during the night.

ACCIDENT DATA

SITE 10: Taylor Road **ACCIDENT PERIOD** 1985 - 1988

NO. OF ACCIDENTS BY YEAR

1985	1986	1987	1988
1		1	2

NO. OF ACCIDENTS BY DAY OF WEEK

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
	2				2	

NO. OF ACCIDENTS BY MONTH

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
					1	1	1	1			

NO. OF ACCIDENTS BY TIME OF DAY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
				1													1		1				1

NO. OF ACCIDENTS BY LIGHT CONDITIONS

Daylight	Dark	Dawn	Dusk
2	1	1	

NO. OF ACCIDENTS BY ROAD CONDITIONS

Dry	Wet	Snow	Ice	Other
4				

NO. OF ACCIDENTS BY WEATHER CONDITIONS

Clear	Rain	Snow	Fog
4			

NO. OF ACCIDENTS BY ACCIDENT TYPE

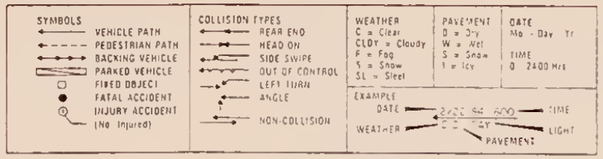
Angle	Rear End	Fixed. Obj.	Ped./Bike	Animal	Sideswipe	Non-Col.	Head-on	Backing	Other
		1				2	1		

NO. OF ACCIDENTS BY POSSIBLE VIOLATION

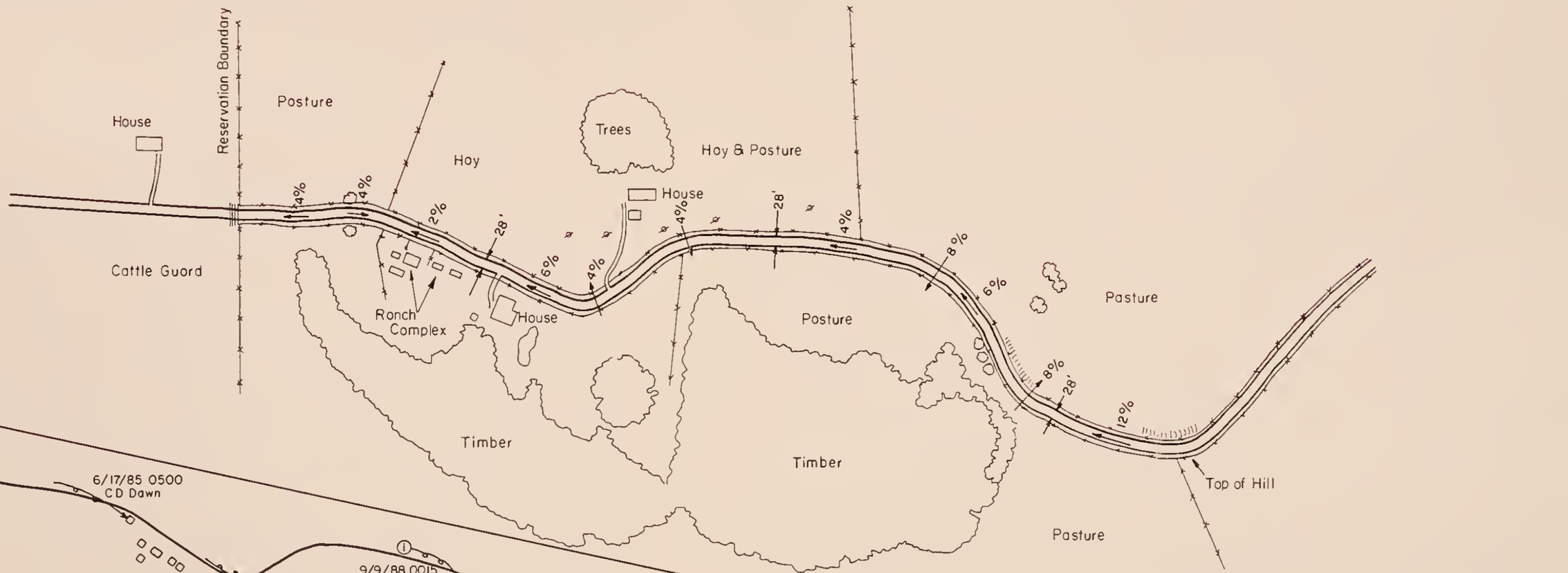
No Ap. Violation	Alcohol/ Drugs	Reckless Driving	Speed	Right-of Way	Improper Passing	Improper Backing	Improper Turning	Other
	3		1					

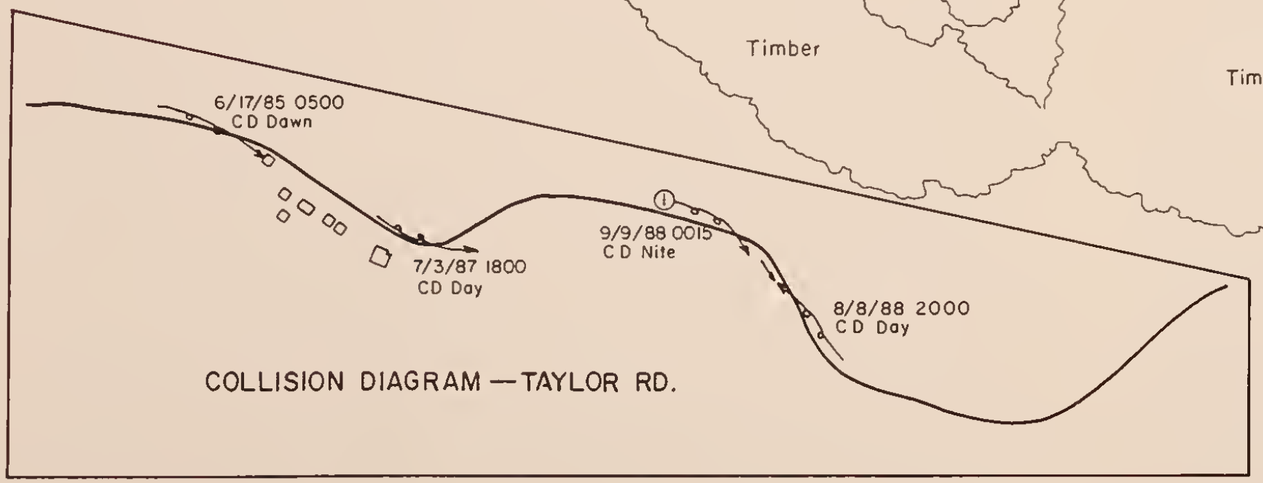
NO. OF ACCIDENTS BY SEVERITY

	1985	1986	1987	1988	Total
Injury Acc. (No. of Injuries)				1 (1)	1 (1)
Fatality Acc. (No. of Deaths)					
Property Damage Only Acc.	1		1	1	3



ESTIMATED AVERAGE DAILY TRAFFIC
230 VPD





COLLISION DIAGRAM — TAYLOR RD.

Approx. Scale 1"=400'

N

Site 10
Existing Conditions &
Collision Diagram
Figure 10A

Recommended Improvements

The accident history at the site indicates that advance warning of the curves would be beneficial. The winding road section that climbs the hill at the east end of the site is of particular concern. A vehicle equipped with a ball bank indicator was used to determine that 35 mph is the maximum safe speed for this set of curves. Warning signs should be used to identify this condition. Warning signs should also be used to identify the reverse curves located in the center of the site. The tangent road sections do not present identifiable hazards to motorists traversing the site. Sight distance is limited at the crest of the hill at the east end, but vehicle approach speeds are relatively low and the accident history does not indicate any problem at this particular location.

The following recommendations address problems and deficiencies at Site 10:

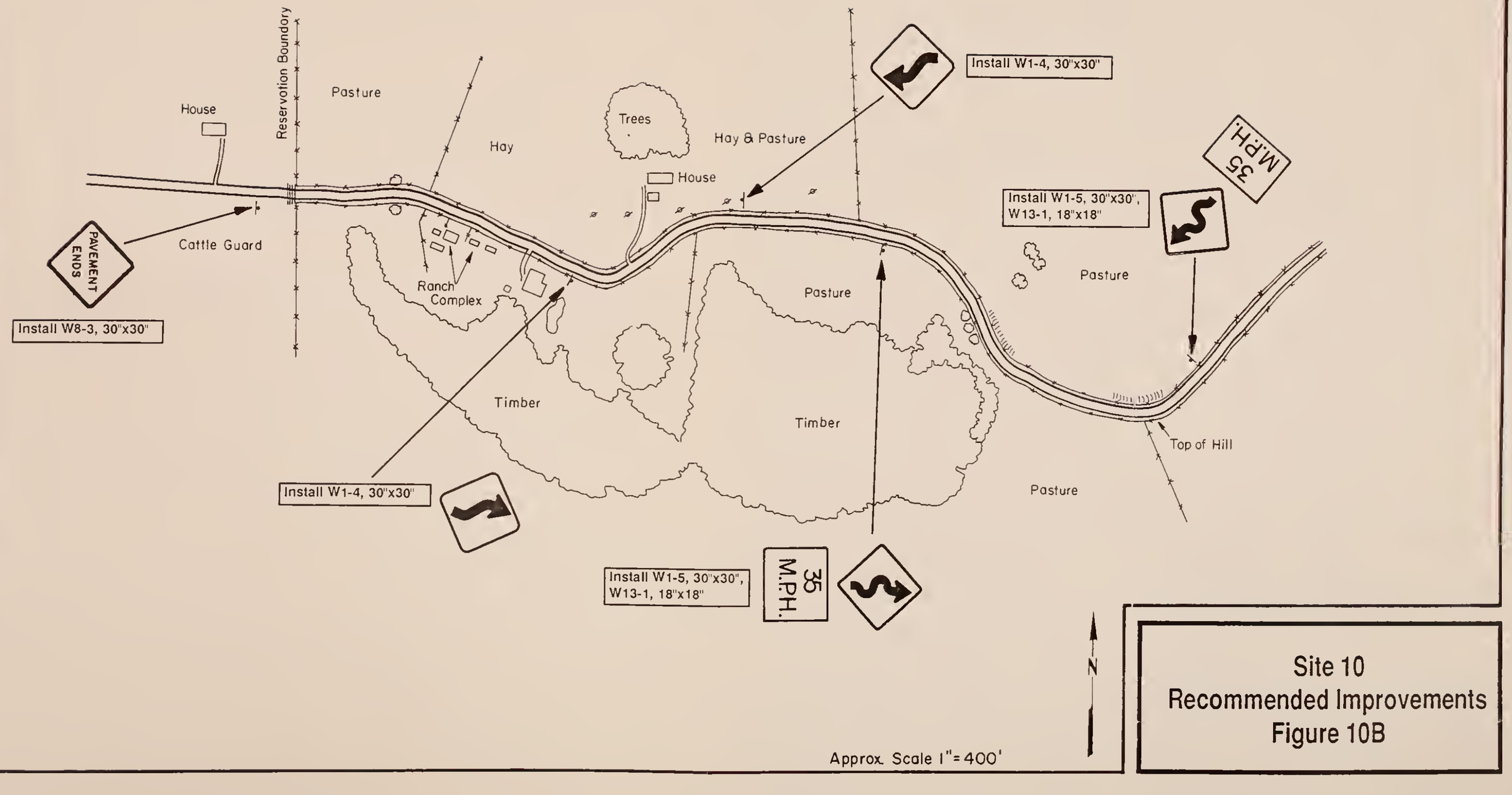
List of Improvements	Estimated Cost
• Install a winding road sign (W1-5, 30"x30") with a "35 mph" advisory speed plate (W13-1, 18"x18") on both approaches to the set of curves at the east end of the site. The signs should be placed approximately 200' in advance of the first curve on each approach (see Figure 10B).	$360.00
• Install a reverse curve sign (W1-4, 30"x30") on both approaches to the curve section of road located just east of the ranch complex in the center of the site. Locate the signs 200' in advance of the first curve on each approach.	280.00
• Install a "Pavement Ends" warning sign (W8-3, 30"x30") approximately 250' west of the cattleguard.	140.00
Total Improvement Costs:	**$780.00**
Benefit/Cost Ratio:	**6.45**

Hazard Index Calculation Form

Site 10: Taylor Road

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	1.00	acc/yr	25	x	0.164	=	4.10
Accident Rate	12.41	acc/MVE	100	x	0.225	=	22.50
Accident Severity	5,125	dollars	48	x	0.191	=	9.17
Volume/Capacity Ratio	0.05		17	x	0.082	=	1.39
Sight Distance Ratio	0.53	(wt. avg.)	93	x	0.074	=	6.88
Driver Expectancy	1.67	(wt. avg.)	28	x	0.149	=	3.92
Information System Deficiencies	2.33	(wt. avg.)	39	x	0.115	=	4.49
		Hazard Index:					52.45
		Cost of Recommended Improvements:					$780.00
		Cost Factor:					96

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)
(52.45 x .75) + (96 x .25) = 63.34



Site 10
Recommended Improvements
Figure 10B

Appendix A

Appendix A: Calculation of the Hazard Index and the Priority Index

A hazard index, based on seven indicator values, was calculated for each study location. Three of these indicators are related to the accident history at the site. They include number of accidents, accident rate, and accident severity. The other four are related to the physical and operational characteristics of the site including the volume/capacity ratio, sight distance, driver expectancy, and information system deficiencies.

A value ranging from 0 to 100 was calculated for each indicator, with 0 representing no hazard and 100 representing the most hazardous condition. The indicator values were then weighted and summed to yield the Hazard Index. The values for each indicator were determined from graphs developed for FHWA Report No. RD-77-83, Identification of Hazardous Locations. The hazard index calculation form shown in Figure A1 includes the weighted values for each indicator.

The costs of the improvements at each site were estimated using current construction costs. A cost factor was determined for the set of improvements at each site. The cost factor represents the improvement costs per vehicle and is computed by dividing the total cost of the recommended improvements by the number of vehicles entering that location over a period of five years. A five-year period is used because it is the average service life of most recommended improvements. The form used to compute the cost factor is shown in Figure A2.

The final phase in the analysis was the determination of the priority index (PI). The priority index is the weighted average of the hazard index (HI) and the cost factor (CF) as shown in the following equation:

$$PI = 0.75\ (HI) + 0.25\ (CF)$$

The site improvements were then ranked according to the priority index.

Improvement costs at each site were also evaluated against the accident-reduction benefits associated with the type of improvement to produce a benefit/cost ratio. The following section contains a brief explanation of the procedures used to calculate each hazard indicator and the benefit/cost ratio for each study location.

Figure A1
Hazard Index Calculation Form

Site _____

Indicator	Data Value		Indicator Value		Weight		Partial HI's
Number of Accidents	_____	acc/yr	_____	x	0.164	=	_____
Accident Rate	_____	acc/MVE	_____	x	0.225	=	_____
Accident Severity	_____	dollars	_____	x	0.191	=	_____
Volume/Capacity Ratio	_____		_____	x	0.082	=	_____
Sight Distance Ratio	_____	(wt. avg.)	_____	x	0.074	=	_____
Driver Expectancy	_____	(wt. avg.)	_____	x	0.140	=	_____
Information System Deficiencies	_____	(wt. avg.)	_____	x	0.115	=	_____

Hazard Index: _____

Cost of Recommended Improvements: _____

Cost Factor: _____

Priority Index = (Hazard Index x .75) + (Cost Factor x .25)

(_____ x .75) + (_____ x .25) = _____

1. Number of Accidents

Accident records for a four-year period from January, 1985, through December, 1988, were obtained from the Department of Justice. This accident data was then used to determine the annual average number of accidents which occurred at each site. The relationship between the annual number of accidents and the indicator value is shown in the graph contained in Figure A2.

2. Accident Rate

This indicator is used to compensate for the wide range of traffic volumes found at each site. The average daily traffic entering each site was calculated and adjusted to represent a four-year volume. The total number of accidents per million vehicles entering the site was then calculated and used to develop the accident rate. The accident rates were entered into the appropriate graph on Figure A2 to yield the corresponding indicator values.

3. Accident Severity

This indicator considers the severity of the accidents which occurred at each site in terms of dollars. Table A-1 contains the "Relative Severity Index" (RSI) which was used to categorize each accident by type and to assign a corresponding accident cost. The average of the RSI values at each site was calculated and entered into the appropriate graph on Figure A2 to determine the indicator value.

4. Volume-to-Capacity Ratio

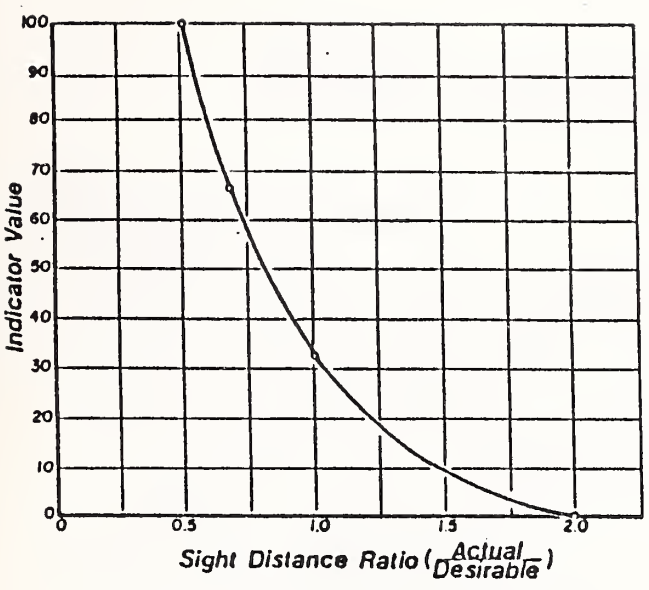
The individual characteristics of the sites vary greatly. This indicator value normalizes each site with respect to lane width, geometics, traffic mix, and volume. The capacity of each site was calculated for Service Level C in accordance with the Highway Research Board, Highway Capacity Manual. The volume used represents the average daily traffic entering the site. The equation used to compute the index is as follows:

$$\frac{V}{C} = \frac{ADT}{24\ (Capacity)}$$

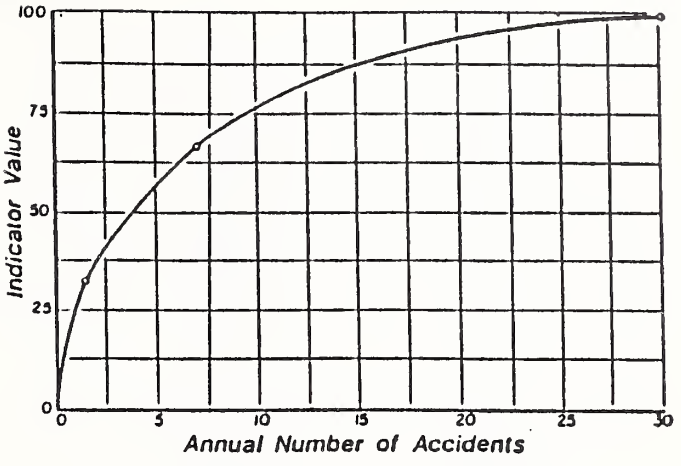
5. Sight Distance

The sight distance that is available at a location is an excellent indicator of the hazardousness of that site. Critical sight distances were measured, and the desirable sight distances for each location were then calculated according to the AASHTO publication, A Policy on Geometric Design of Highways and Streets. The ratio of existing versus the desirable sight distance was calculated for each hazardous location. This sight distance ratio was entered into the appropriate graph on Figure A2 to identify the corresponding indicator value.

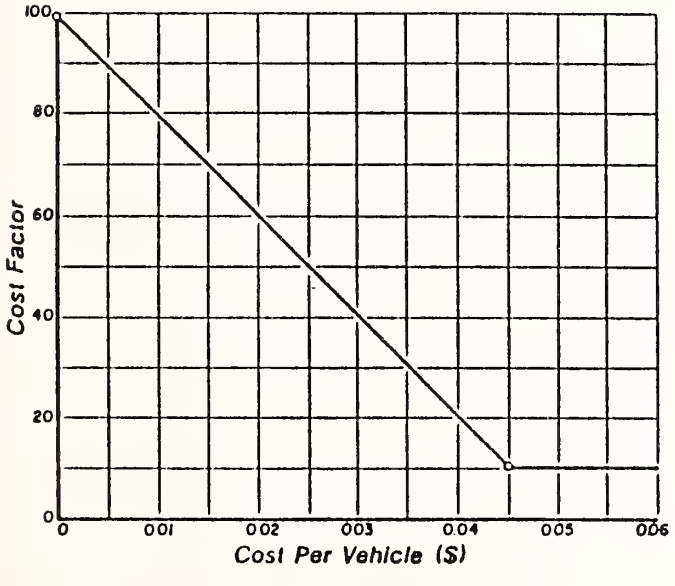
Figure A2
Hazard Indicator Values



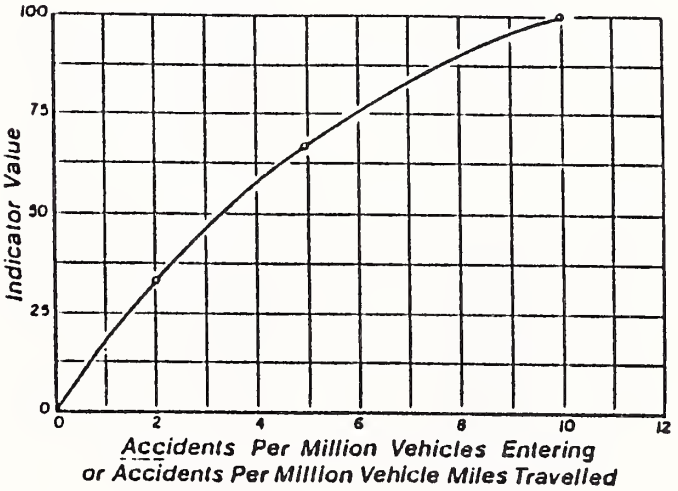
INDICATOR VALUES FOR
SIGHT DISTANCE



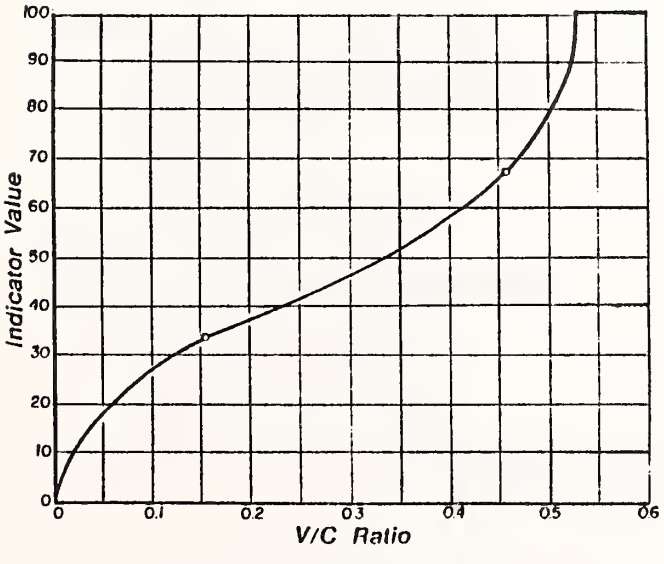
INDICATOR VALUES FOR NUMBER
OF ACCIDENTS



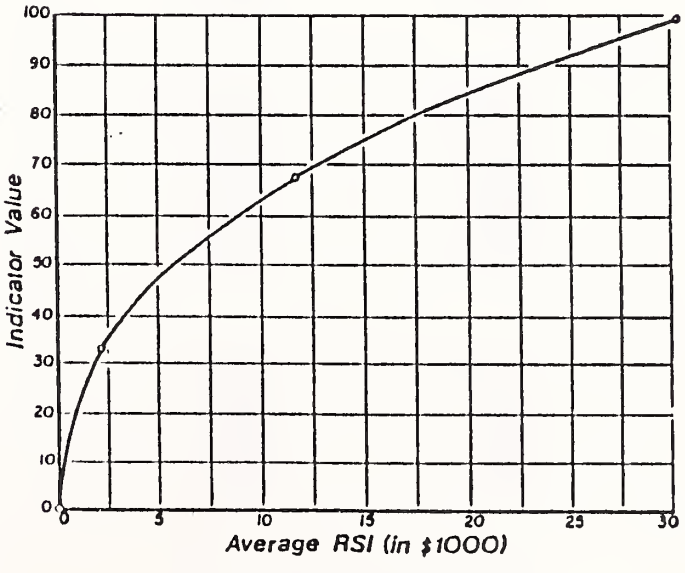
FORM FOR DETERMINATION
OF COST FACTOR



INDICATOR VALUES FOR
ACCIDENT RATE



INDICATOR VALUES FOR
V/C RATIO



INDICATOR VALUE FOR
ACCIDENT SEVERITY

Table A-1
Relative Severity Index by Type of Accident*

	Rural	Urban
Multi-Vehicle, at Intersection		
Entering at angle	$14,400	$ 4,300
From same direction - both going straight	5,100	2,800
From same direction - one turn, one straight	5,100	2,500
From same direction - one stopped	5,200	3,800
From same direction - all others	6,300	2,000
From opposite direction - both going straight	20,000	4,000
From opposite direction - one left turn, one straight	15,400	4,400
From opposite direction - all others	3,800	2,700
Multi-vehicle, Non-Intersection		
Going opposite direction - both moving	$19,600	$ 4,400
Going same direction - both moving	8,100	2,900
One car parked	2,400	1,600
One car stopped in traffic	6,800	4,200
One car entering parked position	2,300	1,900
One car leaving parked position	2,700	1,200
One car entering alley or driveway	6,000	3,400
One car leaving alley or driveway	4,400	2,000
All others	7,600	1,700
Motor Vehicle with Pedestrian, at Intersection and Non-Intersection		
Vehicle going straight	$49,000	$20,000
Vehicle going right	11,200	13,600
Vehicle turning left	11,200	17,100
Vehicle backing	11,200	20,600
All others	11,200	14,500
Single Vehicle, at Intersection		
Collision with train	$39,100	$26,700
Collision with bicycle	31,900	13,100
Collision with fixed object in road	7,000	5,500
Overturned in road	7,500	9,200
Left road	12,300	5,200
Single Vehicle, Non-Intersection		
Collision with bicycle or pedestrian	$31,900	$26,700
Collision with fixed object in road	9,200	6,300
Overturned in road	9,400	10,000
Left road at curve	12,400	7,600
Left road on straight road	10,500	5,200
Other One Motor Vehicle, at Intersection and Non-Intersection		
Fell from moving vehicle	$57,200	$15,000
Collision with animal	1,800	4,800
Collision with other object	4,400	4,700
All others	2,000	5,200

* FHWA-RD-77-87 "Identification of Hazardous Locations"

6. Driver Expectancy

The driver expectancy indicator is a purely subjective method of evaluating the ability of the average motorist to negotiate a section of road or an intersection. Each approach to the site was rated using the criteria included on the driver expectancy form shown on Figure A3. The site was independently evaluated by two technicians and the ratings for each approach were averaged. The two approaches with the worst ratings were used in the calculation of the indicator value. A weighted average of both ratings was calculated and used to compute the indicator value for driver expectancy.

7. Information System Deficiencies

This indicator is based on subjective evaluation similar to the driver expectancy ratings. This rating considers the signing and striping systems at each site with respect to their ability to provide information and guide the motorist through a section of road or intersection. The criteria used in this evaluation are shown on Figure A3.

All approaches to the site were independently rated by two technicians and their ratings were averaged. Only the two worst ratings were used to calculate this indicator. A weighted average of the ratings was used to yield the appropriate indicator values.

8. Benefit/Cost Ratio

Study locations were analyzed and improvements were recommended to address identifiable problems at each site. The costs of the improvements were estimated based on current average construction costs and compared to the accident reduction benefits. The benefits were calculated based on the anticipated accident reduction which may be attainable from various safety improvements. Accident reduction levels were estimated based on figures used by the Planning and Statistics Bureau of the Montana Department of Highways. The method used to calculate the benefit/cost ratios for the high-accident locations is shown in Figure A4.

Figure A3
Rating Forms and Indicator Values for Driver Expectancy and Information System Deficiencies

Driver Expectancy Problems Rating Form

Ratings

0 Nothing unexpected or unusual at this location.
Actions required (if any) entirely consistent with driving strategy on approach.
Standard geometry, with pathway(s) for intended movement(s) clearly evident.
No interferences by other traffic likely.

1

2

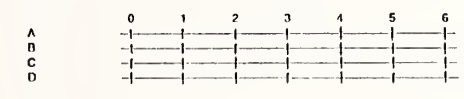
3 Situation somewhat unexpected.
Driver must be alert, but should be able to respond adequately at "last minute" to most combinations of adverse circumstances.
Some initial confusion on intended path(s) or movement(s).
Interference from other traffic may create some degree of confusion or uncertainty for average driver.

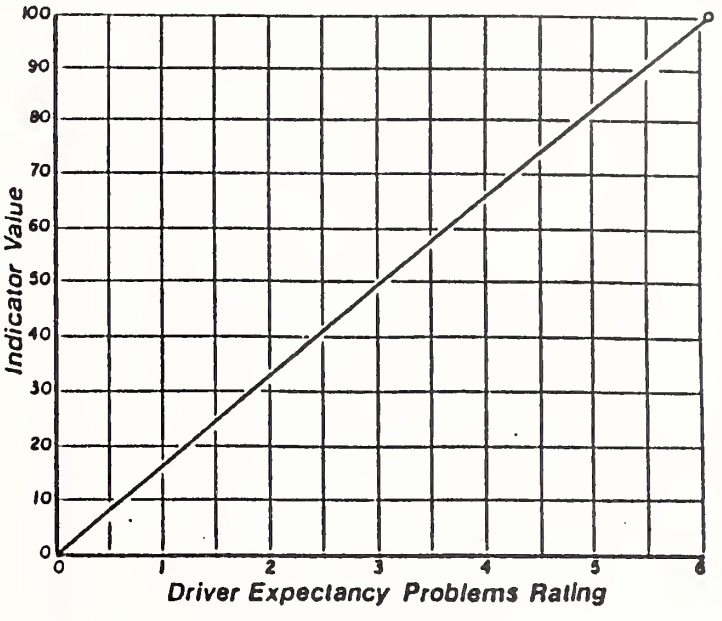
4

5

6 Very unusual situation; will surprise many unfamiliar drivers.
Driver required to make major changes in driving tactics from those employed over the past few miles.
At least a "near accident" almost expected if driver is even moderately inattentive; evasive actions likely to be required.
Intended pathway(s) confusing under fairly normal traffic or lighting conditions.
Other traffic, or lack of it, aggravates situation and misleads driver or deprives him of important cues

Approach — Rating





INDICATOR VALUES FOR DRIVER EXPECTANCY

Information System Deficiencies Rating Form

Ratings

0 Information for required decisions complete and unambiguous.
Signs, markings, delineation in good repair, clean, highly visible.
"Positive guidance" leads driver to appropriate path; makes "error" difficult.
Approach speeds of most drivers are appropriate.
Light decision load; easy and obvious.

1

2

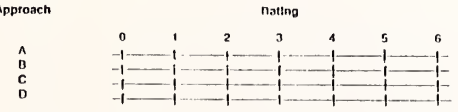
3 Some information lacking or somewhat misleading.
Signs should be moved or augmented for better visibility or to provide more decision time.
Visibility of signs, marking, and delineation barely adequate.
Medium decision load; average driver will be able to handle situation, but may be a little uncomfortable.

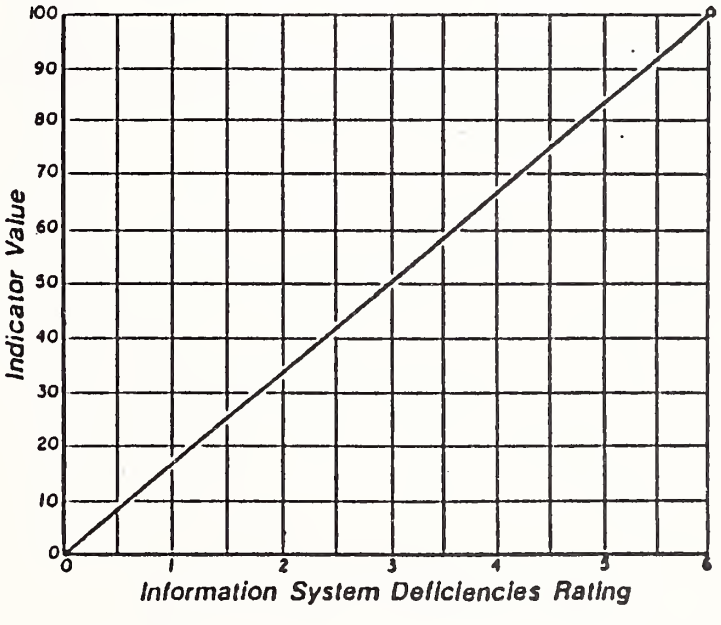
4

5

6 Important information missing.
Complete new "information system" needed - design and installation.
Present signs and markings in very poor condition; need replacement.
Speed limit and/or advisory speed needed; either missing or totally inappropriate at present.
"Positive guidance" on appropriate path lacking; a clutter of negative delineation only.
Heavy decision load; complete attention of average driver required; a "tense" situation at best.

Approach — Rating





INDICATOR VALUES FOR INFORMATION SYSTEM DEFICIENCIES

Figure A4
Benefit/Cost Ratio Calculation Form

Benefit/Cost Ratio

Location: _____ Milepost: _____

Improvement Description: _____

_____

Estimated Service Life _____ Years = T

Compounded Interest Rate _____ % = R

Current 19____ ADT _____

Time Frame for Accident Date: From _____ to _____ = _____ years

I. Annual Cost for the Improvement

1. C = Capital cost for improvement $ _____
2. K = Capital recovery factor $K = \frac{R(1+R)^T}{(1+R)^T - 1}$ =
3. M = Change in annual maintenance or operation cost $ _____
4. Annual cost =(C K) + M = $ _____

II. Annual Benefit of the Improvement

1. ADT_a = Average daily traffic after improvement: _____
2. ADT_b = Average daily traffic before improvement: _____
3. I/F = Ratio of injuries to fatalities for the class of highway involved _____
4. $\frac{Q = * + (I/F)^{**}}{1 + I/F}$ = _____

* Current cost of a fatal accident = $500,000

** Cost of an injury accident = $12,400

5. Afi = Annual average number of fatal accident and injury accidents combined at the location which will be affected by the improvement =

   $\frac{\text{No.}}{\text{Years}}$ = _____ = _____

6. Apd = Annual average number of property damage accidents at the location =

   $\frac{\text{No.}}{\text{Years}}$ = _____ = _____

7. Pfi = Expected percentage reduction of fatal and injury accidents by improvement = %
8. Ppd = Expected percentage reduction of property damage accidents by improvement = %
   a. P1 = Largest percentage in accident of any one of the improvements.
   b. P2 = Second largest percentage reduction in accident of any one of the improvements.
   c. P3 = Third largest percentage reduction in accident of any one of the improvements.
   d. Pfi and Ppd for location where more than one improvement will be used in combination =

   $P1 + \frac{100 - P_1}{100} P2 + \frac{100 - P_1}{100} \frac{100 - P_2}{100} P3 + \ldots$

9. Annual benefit $\frac{ADT_a}{ADT_b}$ [Q(Afi)Pfi = *** (Apd) Ppd] =

***Cost of a property damage accident =$1,500

III. Benefit/Cost Ratio

Benefit/Cost Ratio = $\frac{\text{Annual Benefit}}{\text{Annual Cost}}$ = _____ =

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